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US Army Corps of Engineers
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Technical Report 83-TR-1
May 1983

AD-A225 744

Methods, Models And Data Sources Applicable To Transportation Economics Studies

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Unclassified

SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

Form Approved
OMB No 0704-0188
Exp Date Jun 30, 1986

1a. REPORT SECURITY CLASSIFICATION Unclassified	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release: Distribution Unlimited
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S) Technical Report 83-TR-1	5. MONITORING ORGANIZATION REPORT NUMBER(S)
6a. NAME OF PERFORMING ORGANIZATION Water Resources Support Center Institute for Water Resources 6b. OFFICE SYMBOL (If applicable) CEWRC-IWR-N	7a. NAME OF MONITORING ORGANIZATION
6c. ADDRESS (City, State, and ZIP Code) Casey Building -Building #2594 Ft. Belvoir, VA 22060-5586	7b. ADDRESS (City, State, and ZIP Code)
8a. NAME OF FUNDING/SPONSORING ORGANIZATION 8b. OFFICE SYMBOL (If applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
8c. ADDRESS (City, State, and ZIP Code)	10. SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO. / PROJECT NO. / TASK NO. / WORK UNIT ACCESSION NO

11. TITLE (Include Security Classification)
Methods, Models and Data Sources Applicable to Transportation Economics Studies

12. PERSONAL AUTHOR(S)
Morris William Clark, Jr.

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
	FROM ____ TO ____	83 May	192

16. SUPPLEMENTARY NOTATION

17. COSATI CODES		
FIELD	GROUP	SUB-GROUP

18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
Waterways, inland & national waterways, ports, harbors, transportation, water resources, navigation, navigation analysis, waterborne commerce & commodity flows, locks

19. ABSTRACT (Continue on reverse if necessary and identify by block number) This technical report is a reference handbook that provides concise descriptions of a selected group of currently used methods, models and data sources which are applicable primarily to transportation economics studies of the Nation's inland navigation system. This report was designed to be useful to novices as well as experts in transportation economics and navigation analysis. This report consists of three chapters and a glossary of more than 250 terms that are applicable.

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT ☐ UNCLASSIFIED/UNLIMITED ☒ SAME AS RPT. ☐ DTIC USERS	21. ABSTRACT SECURITY CLASSIFICATION Unclassified
22a. NAME OF RESPONSIBLE INDIVIDUAL Morris William Clark, Jr.	22b. TELEPHONE (Include Area Code) (202) 355-3085 22c. OFFICE SYMBOL CEWRC-IWR-N

DD FORM 1473, 84 MAR — 83 APR edition may be used until exhausted. All other editions are obsolete.

SECURITY CLASSIFICATION OF THIS PAGE

Unclassified

Methods, Models and Data Sources Applicable to Transportation Economics Studies

by

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May 1983

Technical Report 83-TR-1

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FOREWORD

This U.S. Army Corps of Engineers (CE) technical report is a reference handbook that provides concise descriptions of a selected group of currently used methods, models and data sources which are applicable primarily to transportation economics studies of the Nation's inland navigation system. This report consists of three chapters and a glossary of more than 250 terms that are particularly applicable to the transportation industry.

Chapter I is a brief introduction to the background and implementation of the Inland Navigation Analysis (INSA) Program, which led to the development of the computer models and other computer applications that are discussed in Chapter II. Chapter III is devoted to descriptions of data sources data bases and data files) that are applicable to transportation economics studies and are maintained and/or sponsored by the Navigation Analysis Center (NAC); the NAC is a component of the Institute for Water Resources (IWR) that is located at the Water Resources Support Center (WRSC). The data sources cited in Chapter III are generally useful in the conduct of deep draft and shallow draft studies, but are not exclusively for INSA applications.

This summary report was published by the Navigation Analysis Center. Mr. Morris William Clark, Jr., an NAC economist, wrote this report under the managerial oversight of Mr. Francis M. Sharp, Chief of the NAC. During the creation of this report, COL Maximilian Imhoff, CE, was the Commander and Director of the WRSC, and Mr. James R. Hanchey was the Director of the IWR.

The author gratefully acknowledges the assistance of the numerous persons who contributed to the conception and preparation of this report. Among the many contributors, the author`s NAC colleagues, Ms. Marilyn V. Fleming, Messrs. Francis M. Sharp, David F. Bastian, James G. Gould, John M. Lane, Dr. Arthur F. Hawnn, and Ms. Kathleen Ann Grosshans, have been foremost in providing encouragement, constructive criticism, and substantive background information. A special indebtedness is hereby acknowledged for the contribution of Ms. Marilyn V. Fleming, who was instrumental in the development of the glossary and in the providing many valuable suggestions on all parts of the report.

A substantial portion of this summary report is based on the published reports of the INSA Program which was initiated under the direction of Mr. DuWayne Koch; consequently, the author is grateful to all of the INSA Program participants who helped to produce the INSA reports. The author is also indebted to Mr. Michael R. Walsh, who at the outset made helpful suggestions regarding the report's structure and formats; to Ms. Barbara Anne Stevenson, an IWR editor, who patiently helped to develop the formats of the manuscript; to Ms. Joyce Watts Hardyman, a WRSC editor, who, pursuant to the author's requests for advice, made many helpful suggestions as the report approached completion.; to Mr. David L. Penick and Ms. Sherry L. Plummer, both of whom assisted in development of the sections on the waterborne commerce statistics; to Mr. David Weekly and Dr. Larry Daggett, both of whom provided background information on development of the CE navigation analysis models; to Mr. James Tang and Dr. Jerome Delli Priscoli, both of whom conducted sensitivity reviews of draft manuscripts; to Mr. Steve Mueller, who provided information that was used in development of the sections on the data sources maintained for the Corps of Engineers at Data Resources, Inc.; to Dr. Lloyd George Antle and Mr. Brad Fowler, both of whom reviewed the final draft and suggested meaningful changes that were incorporated into this manuscript; and to Ms. Patricia M. Brundage, Ms. Linda L. Clark, Ms. Linda A. Newell, Ms. Rosalind H. Peggs, and Ms. Rebecca Woodward-Davis, all of whom handled masterfully the repetitive typing of this report.

The Navigation Analysis Center proposes to provide update addenda to each edition of this report as soon as practicable when necessary and to publish complete editions of this report on a biennial basis. The author assumes complete responsibility for all errors contained in this report. Comments on this report are invited.

CHAPTER I
AN OVERVIEW

Introduction

The U.S. inland waterway system (network) is a creation of the U.S. Corps of Engineers, and consists of more than 25,000 miles of navigable channels, canals, reservoirs and lakes. The Corps accomplished this task largely by using lock and dam structures, dredging, and river training to convert existing rivers into a navigable waterway network. The Mississippi River and the Gulf Intracoastal Waterway (GIWW) systems are the major components of this network and are the primary areas of waterway concern within this report. The Mississippi-GIWW system accounts for about 55 percent of the waterway length, 70 percent of the waterborne ton-miles, and 85 percent of waterborne tonnage in the U.S. (See Figures 1 and 2.)

Lock and dam structures occur primarily on the GIWW and along the upper reaches of the Mississippi and its tributaries. On the GIWW, lock and dam structures serve primarily to control tidal flows and prevent salt intrusion into freshwater. On upper river reaches, lock and dam structures convert open river into navigable pools. The dam creates the pool, and the lock lets traffic pass through the dam from one pool to the next. Recently, however, problems have begun to arise. First, growth in traffic has resulted in severe congestion and traffic delays in certain portions of the waterway network. In addition, some of the system's lock and dam structures are approaching the end of their useful physical lives. Finally, environmental difficulties with dredge material disposal are hampering the Corps' ability to maintain adequate channel depth.

In 1973, the Corps established an Inland Navigation Systems Analysis Coordination Group to develop the Inland Systems Analysis Program (INSA) which was given the assignment to try to solve the congestion and other problems. A major INSA objective was to implement procedures that would bring together models and data to estimate, within a market framework, the probable benefits and costs for alternative versions of the inland waterway system. The INSA became an integrated system of models, data bases and planning procedures that were developed to explain, predict and plan for U.S. inland waterway transportation. The ultimate set of INSA models includes a Commodity Flow Model (CFM), a multimodal Transportation Freight Model (TFM), an inland waterway Tow Cost Model (TCM), a Lock Capacity Function Generator (LOKCAP), and an inland Waterway Analysis Model (WAM). The INSA also obtained and compiled data bases that could be used to describe and analyze commodity flows, economic patterns, national transportation networks, transportation costs and rates, the inland waterways, and the inland waterway towing industry.

FIGURE 1

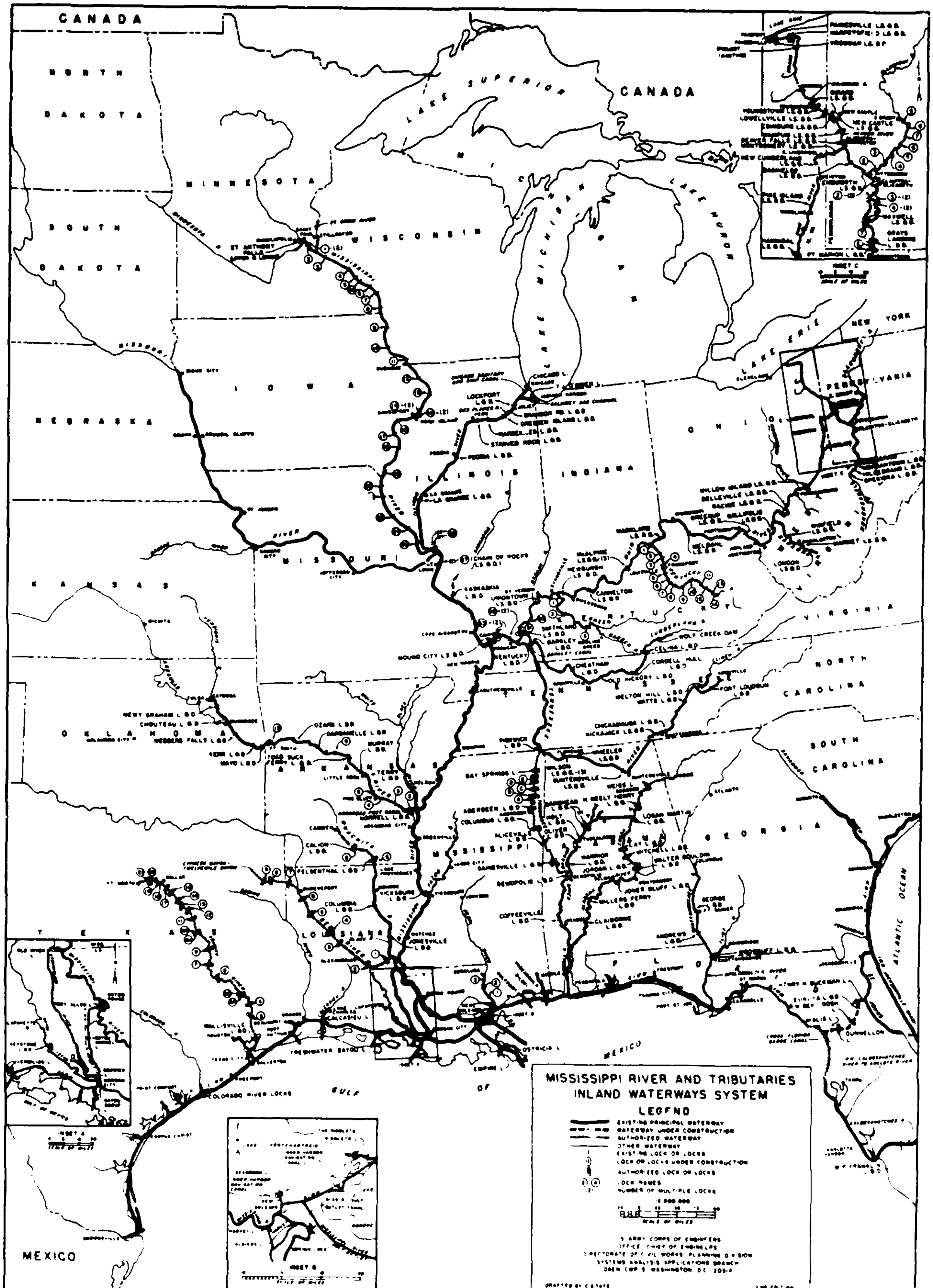
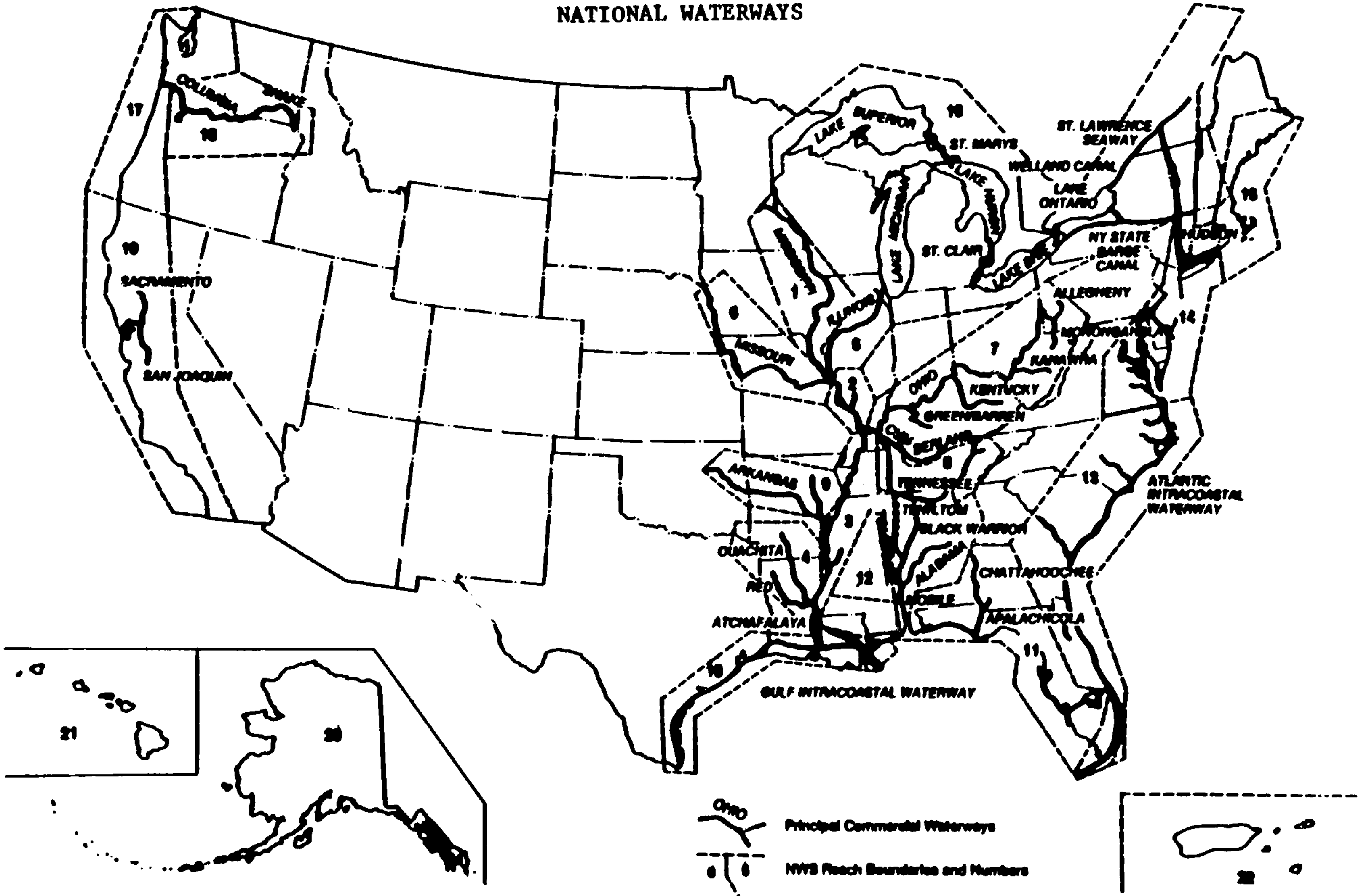

CANADA
NORTH DAKOTA
SOUTH DAKOTA
MINNESOTA
WISCONSIN
LAKE SUPERIOR
CANADA
LAKE MICHIGAN
LAKE HURON
LAKE ERIE
NEW YORK
PENNSYLVANIA
IOWA
NEBRASKA
ILLINOIS
INDIANA
OHIO
KANSAS
MISSOURI
KENTUCKY
VIRGINIA
NORTH CAROLINA
OKLAHOMA
ARKANSAS
SOUTH CAROLINA
MISSISSIPPI
GEORGIA
LOUISIANA
TEXAS
ATLANTIC OCEAN
MEXICO
MISSISSIPPI RIVER AND TRIBUTARIES
INLAND WATERWAYS SYSTEM
LEGEND

FIGURE 2
NATIONAL WATERWAYS



1. Upper Mississippi River
2. Lower Upper Mississippi River
3. Lower Mississippi River: Cairo to Baton Rouge
4. Lower Mississippi River: Baton Rouge to Gulf
5. Illinois Waterway
6. Missouri River
7. Ohio River System
8. Tennessee River
9. Arkansas River
10. Gulf Coast - West
11. Gulf Coast - East
12. Mobile River and Tributaries
13. South Atlantic Coast
14. Middle Atlantic Coast
15. North Atlantic Coast
16. Great Lakes System
17. Washington/Oregon Coast
18. Columbia - Snake Waterway/Willamette River
19. California Coast
20. Alaska
21. Hawaii and Pacific Territories
22. Caribbean

Source: National Waterways Study ◻ U.S. Army Engineer Water Resources Support Center ◻ Institute for Water Resources

The Towing Industry

Along the waterway network, a very competitive towing industry, exceeding 1,800 companies, is engaged in commercial transportation. These companies also operate a fleet of over 4,300 towboats and 28,700 barges and account for about 15.4 percent of the Nation's intercity freight tonnage and ton-miles. Major waterborne commodities include petroleum, coal, iron ore, chemicals, grains, sand and gravel.

Another major INSA objective, correct anticipation of towing industry (and shipper) actions, of course, is one of the prerequisites for effective management of the inland waterways. One of the striking features of inland waterway transportation is the variety of vessel types and operating patterns which have been developed in response to specific shipper needs. This variety and the independent entrepreneurial nature of most carriers sometimes makes it difficult to anticipate what the towing industry will be like in the future. Fortunately, however, the relatively stable makeup of the commodity set which accounts for most inland waterway traffic, combined with the observed efficiency-seeking propensity of most barge lines, makes it possible to predict with reasonable confidence how the industry will respond to externally imposed conditions, such as alterations in the physical and operational characteristics of the inland waterway system.

Dry cargo barges on the Mississippi River system are almost entirely jumbo hopper barges, 195 feet long and 35 feet wide, with a carrying capacity at 9-foot draft of 1,500 tons. Hopper barges are sometimes fitted with water-tight covers, but the majority are "open hoppers" in which the cargo is exposed to the elements. Bulk liquid commodities are moved in a variety of tank barges ranging in capacity from 1,000 to 3,000 tons. Specialized equipment is frequently used for chemicals and other commodities.

In the recent past, the most common towboat had about 500 horsepower. Now most line-haul towboats are over 100 feet long and some of the more powerful are almost 200 feet in length. These towboats usually have 2,000 to 8,000 horsepower, although some recently launched boats have as much as 10,000 horsepower. For example, tows of up to fifty 1,500-ton barges, propelled by 10,000 horsepower diesel towboats, regularly traverse the Lower Mississippi from Cairo to Baton Rouge; each such tow is equivalent to 15 freight trains each containing a hundred 50-ton freight cars.

A rapid increase in unit power (and a corresponding increase in tow size) is the most significant trend in commercial fleet development. Unit towboat horsepower over the U.S. waterway network increased by about 40 percent between 1967 and 1973. Flotilla utilization, with oscillations of 10 percent to 13 percent, has been relatively stable. Considering the myriad factors which influence this statistic, this deviation may be considered to be insignificant and indicates that towboat utilization has reached equilibrium under present conditions.

Line-haul towboats are normally kept underway, continually picking up and dropping off barges at fleeting areas. A medium-sized towboat (2,000 to 4,000 horsepower) may be used to collect loaded barges along the Illinois or Upper Mississippi waterways and carry them south to the confluence of the Mississippi and Ohio Rivers at Cairo, Illinois. At Cairo, the barges may be delivered to a larger towboat (up to 10,000 horsepower) to form tow of up to 50 barges which is then pushed south to New Orleans. The delivering towboat is turned upstream with barges either originating at Cairo, or towed there from some other point on the network. At New Orleans, the load will be dropped off and may be broken up into a number of smaller tows, shipped to local area unloading docks, or moved along the GIWW. During periods with reduced transportation demand, companies generally prefer to keep part of their towboats idle and maintain the same size of tow (that which is efficient for a particular waterway segment) year round, rather than operate with all boats available and smaller tow sizes.

In recent years, there has been greater use of integrated tows, which are moved as a unit from origin to destination by the same towboat without picking up or dropping off other barges (the waterway equivalent of unit trains). The entire unit is lashed together to form one streamlined vessel that is composed of a bowpiece, a number of square-end barges and a towboat. Integrated tows are economically efficient for repetitive large volume movements with relatively small ratios of port time to en route time, and have been used mainly for petroleum products.

Shipping interests are now developing new types of vessels which are designed to speed international shipping by avoiding reloading time and warehouse congestion at ocean terminals. These new operating concepts are known as LASH, SEABEE and MINISHIP, with the first two designed primarily for trans-Atlantic runs and the third limited to Latin American shipments. The LASH and SEABEE systems use specifically designed river barges which may be loaded at any port on the inland waterways, then towed to an ocean port where they are loaded on a special ocean-going ship. The ship unloads the barges at major overseas ports, from which they are then towed to various inland destinations on foreign waterways. SEABEE barges have dimensions of 95 x 35 feet, or about half the size of a jumbo barge, while LASH units are 70 x 31 feet. MINISHIPS, with a draft of just 9 feet while carrying 1,000 tons of general cargo, are now serving inland ports as far north as St. Louis, and sail directly to Latin American ports, completely bypassing ocean ports.

The set of waterway models described herein serve two major purposes. First, they generate waterway cost and capacity functions needed for transportation market impact analysis. Second, the models allow very detailed physical waterway planning, so that physical performance and economic impacts may be closely associated and clearly understood.

It should be noted that the estimated performance characteristics of the waterway system are generated at three levels of detail -- abstract, intermediate and detailed -- corresponding respectively to the outputs of the multimodal Transportation Freight Model, inland Tow Cost Model and the inland Waterway Analysis Model. These three levels of outputs are all used for various types of system evaluations. At the most abstract level, the waterway performance outputs are directly comparable to similar outputs that characterize the other modes. It is also at this level that interregional transportation cost information is made available for use as input to the Commodity Flow Model.

CHAPTER II
SELECTED METHODS AND MODELS

Introduction

This chapter contains abbreviated descriptions of the major methodologies and computerized models that are currently used and/or sponsored by the U.S. Amry Corps of Engineers, in the conduct of navigation analyses of the Nation's inland waterways. The pertinent user manuals, containing greater detail than that in the aforesaid abbreviated descriptions, are listed in the reference section of this report.

The following set of methodologies and models was selected to exhibit some currently used ways to diagnose inland waterway transportation problems and to generate and test proposed solutions. Typical problems treatable by the set of methods and models include:

- Waterway congestion and delay
- Limited disposability of dredge spoil
- Deteriorating structures requiring replacement

The set of methods and models can also predict when, where, and to what extent transportation problems may arise from events external to the inland waterway. Such external events could pertain to:

- Development of U.S. western coal reserves
- Increased export demand for grain
- Depletion of mineral reserves
- New transportation technology (slurry pipelines)
- Rail line consolidation
- Technical innovation in other industries
- Revised waterway operating policies, including lockage priority rules, ready-to-serve lockage policy, and lockage assistance
- Reduced dredging requirements, selected so that reduced channel depth and reliability cause a minimum reduction of navigation benefits
- Increased investment in the waterways, including replacement projects, building new waterways, abandoning existing waterways, and investing in alternative modes

Given any of the above waterway problems or external events, the resultant transportation and economic impacts can be identified and traced through simulations of problems and solutions analyzed in terms of their effects on transportation cost or capacity. The model descriptions follow this introduction.

MODEL TITLE: COMMODITY FLOW MODEL

CODE NAME: CFM or CFMODEL

WRITER:

CACI, Inc.
1815 North Fort Myer Drive
Arlington, VA 22209

Telephone Number: (703)841-7800

PREVIOUS APPLICATIONS: An energy commodities movement study was conducted by the U.S. Department of Energy in Washington, D.C.

LOCATION AND AVAILABILITY: The model source code, model object code, and some sample data are stored on magnetic tapes at the Boeing Computer Services Company (BCS) in Bellevue, Washington. Corps personnel with a valid BCS account number may access the tapes on-line and make model runs on the BCS system. The serial numbers and characteristics of the tapes may be ascertained by contacting the navigation analysis center. Other Corps personnel desiring to make model runs or access the tapes on-line or obtain copies of the tapes are also advised to contact the:

Navigation Analysis Center
Institute for Water Resources
U.S. Army Corps of Engineers
Casey Building
Fort Belvoir, Virginia 22060
Attn: Mr. Francis M. Sharp

Telephone Number: (703) 325-0574

DEVELOPMENT STATUS: Completed

DOCUMENTATION STATUS: Completed

MODEL OVERVIEW

From the perspective of the Commodity Flow Model (CFM), the United States economy consists of a set of regions. Each region contains a set of economic sectors or industries. Each economic sector produces an output product to satisfy the demand that it perceives; this demand may include domestic consumer demand, export demand and demands from other economic sectors. The production process requires that each sector combine raw materials, labor and capital goods to produce its output product. The mix and sources of resource inputs to production depend upon delivered input prices, which include the price of transportation, as each sector seeks efficient input combinations. Within this system, commodity flows occur as input raw materials travel to the sectors demanding them and as output products travel to locations of domestic consumer demand, export demand and economic sector input demand.

The CFM is a multiregional input-output model in which market dynamics determine the location, composition and pricing of output, and the behavior of economic aggregates determines the level of output. Within this multiregional economic system, firms and households select commodity suppliers, and producers compete for customers on the basis of delivered price. This delivered price includes the price of transportation from supplier to consumer and also the transportation cost built into free on board (FOB) prices because of transportation charges for gathering raw materials. Therefore, the CFM generates a demand for transportation which depends in part upon transportation price.

Commodity Traffic and Transportation Market Analysis

The CFM is a component of a model system that describes the multimodal transportation market. Within the CFM framework, production, consumption and transportation are represented as transactions that are generated and linked together in a dynamic adjustment process. These transactions are the economic basis for the planned commodity traffic flows that constitute the effective demand for transportation. Modal-choice decisions convert this planned traffic into effective demand for transportation by each mode. The structure, costs and capacity of a modal network define the supply of transportation offered by each mode. Supply and demand then jointly determine transportation price and service levels.

The market elements, consisting of modal choice, transportation supply and transportation market equilibrium, are portrayed within the Transportation Freight Model (TFM), discussed later in this section. Transportation market price, as determined within the TFM, is then returned to the CFM to help guide further economic transactions.

CFM PROGRAM STRUCTURE AND LOGIC

The CFM produces forecasts of annual commodity flows, demand calculations, and key parameters for each simulated year. The bulk of the required input parameters including activity, sector, demand transport cost, personal consumption and regional income attributes. Both checks can be made for completeness and format conformance; playback reports are available.

The model uses successive approximations to approach the values forecast for commodity flows. A test for correspondence or convergence between the last two approximations is made; failure to converge leads to additional processing. Success in the test initiates computation of domestic commodity demand for the upcoming simulated year. The number of iterations of the activity and flow logic and convergence test, which largely determine computational cost, are minimized by sector numbering as discussed below.

A variety of economic processes are represented within the CFM. Demand, production, distribution and pricing of commodities appear in the model at various levels of detail. A definition of the structure of the economic system and the manner in which elements are represented follows. Economic activities should be chosen so as to correspond with one specific commodity. For example, "petroleum production" may be defined as an activity, with "petroleum products" being the commodity. In the CFM, it is assumed that a sector's activity results in the production of one commodity and the term "activity" or "commodity" may be used interchangeably.

- Sector Ordering: Activities are best arranged in reverse of "natural order." By natural order it is meant that raw materials are extracted first, with successive processing and assembly following. An example of reverse natural order is: electrical machinery, wire manufacture, copper manufacture, and then copper ore extraction. This ordering recognizes that indirect demand is generated primarily by the activities that are last in sequence of production. In general, primary activities depend to a greater extent on indirect demand rather than on secondary or tertiary activities, which reflect more final domestic demand. The model relies on final demand being given, with the resultant indirect demand being calculated.

- Minimum Cost and Location: The initial calculations made in the model are minimum delivered prices of each commodity for each consuming region and each source supply region. Delivered price is defined as the sum of the FOB price and transportation cost.

  Prices are generally based on the unit cost of production. The production model determines quantities of required labor, capital and commodities; the quantities, weighted by factor unit cost, may be summed to yield total expenditure by the sector. The expected unit cost of production may be determined by the ratio of expenditures to total production. It follows under the previous conditions that price will not vary with magnitude of production (unless capacity is exceeded).

  If sector production exceeds a constraint maximum, the FOB price is altered. When the quantity demanded is greater than the total a sector can produce, the model attempts to produce what is demanded, but at a higher price. In later iterations, therefore, other sectors will cease to consider the constrained sector as a viable supplier.

- Allocation of Demand: When the approximations of economic activity and commodity flow have converged toward equilibrium, the model then has an estimate for one simulated year. Before the following year's simulation is commenced, the domestic demand for commodities by individuals, institutions and activities not covered by the model is estimated.

  Expected regional population of a region is determined by multiplying the expected ratio of population to work force and the work force of all sectors within a region. Per capita wage income by region determines the region's share of national capital return income. Regional wage income is found by summing work forces weighted by wages for every sector in a particular region.

  Given income by region, the personal consumption expenditure function may be introduced to establish each region's requirement for consumer goods. This expenditure is an expression of the dollar demand for commodities, and is used by the model to reflect the unitary elasticity of price and quantity of goods demanded.

  Model logic treats demand or purchasing regions (aggregations of individuals and firms) as rational, economic decision-making units. Demand by domestic or foreign markets by location is satisfied by production regions offering the lowest delivered cost. The allocation of demand by market to production regions defines a portion of the commodity flows as well as the demand for each regional sector's output.

  During demand allocation, no direct checks are made to determine if new quantity demanded exceeds sector capacity. The problem of demand exceeding capacity is handled by incrementing FOB price until quantity demanded does not exceed capacity.

- Final and Intermediate Demand: Export demand for commodities is entered for the first simulated year; for subsequent years only changes are required. The model computes expected domestic demand for each year but the first, based on historical patterns of national income and expected wages. Intermediate demand which results from requirements of economic activity is computed internally.

  The hub of the CFM is the regional production model. The model represents decisions made by a collection of firms within an area. The decisions are based on the total quantity demanded of the firms by all other markets. Assuming for the moment that there is no demand from production sectors, the demand would comprise final domestic demand and export demand. Given that quantity, the sector scans its potential sources of supply to find the best region in which to acquire necessary raw materials or components. Based on the prevailing wage, price of capital, and the delivered prices of needed material, the sector aggregates the factors in the lowest cost combination to produce the demanded quantity. Given the quantity of input material required from other sectors and the minimum cost location, the model defines a portion of total commodity flow and indirect demand. Sectors that are evaluated later base production on indirect and final demand.

The model maintains a table which reflects the quantity produced based on final demand, indirect demand for sectors that have already been evaluated, plus any anticipated indirect demand that may come from sectors yet to be evaluated. The table also reflects demand for commodities that was unanticipated by the sector in the production model or backflow. During each successive approximation or iteration of the model, unanticipated demand becomes relatively small in comparison to what is produced. Convergence is considered to have occurred if most of the sector's unexpected demand becomes insignificant. Insignificance is defined by the model user as the convergence parameter.

- Transportation Cost: Costs are entered externally so that detailed transportation cost models like the INSA TFM may be used externally to estimate transportation costs. Any set of costs may be entered to analyze potential policies or unusual events.

- Scenario Bank and Specified Alterations: As the data required for a forecast are detailed and extensive, most applications will most likely begin with a standard scenario. Activities, regions and sectors are already established as are initial prices, production function parameters and initial final demands. Changes to the scenario or entirely new scenarios may be prepared using input forms. Initial model routines will check input data for completeness and certain types of errors.

- Economic Activity Forecasts: Production in any sector is driven by demand comprised of export demand, domestic final demand and demand created by other economic activities. Given the prevailing prices of production factors, the minimum cost mix of factors is employed to produce desired demand. Production factor quantities used by the sector are thereby defined, including commodities required from other sectors. The prices of inputs and the amounts consumed determine the FOB price of that sector's commodity.

  A number of calculations in the model require the price of production input material. Because most activities require input of more than onecommodity, a single value of "price of material" must combine the relative quantities of required commodities weighted by their respective prices. Assuming that each sector will choose the source affording the lowest delivered price, then prices will change through simulated time, and the composite material price must then be recalculated.

- Commodity Flow Allocation: Input materials required for production by a sector are allocated to other sectors for production. The criterion for sector selection is minimum delivered cost, which is the sum of FOB price in the producing sector plus transportation cost between regions.

- Consumption Computation: Wages paid by each sector contribute to the income of consumers in a region. Household income derived from distributed returns to capital is allocated to regions on the basis of per capita earned income. Regional income is then spent or converted to demand for commodities and services using an aggregate household consumption function.

INPUT DATA REQUIRED

Operation of the model requires that an extensive set of data be specified by the analyst. The format of the data and prepared data packages for the model are presented in the User's Manual. The data used in calculations by the model are presented below:

- Activity Attributes: The definition of activities will determine the degree to which reliable data may be gathered, as well as the accuracy and completeness of forecasts. Irrespective of the region in which an activity is located, an activity may have material requirements. A user should be able to specify the commodity required and the relative requirements of each commodity. Commodities are identified as output from an economic activity. Each activity has a production function type, a mix of required input commodities and a unit measure. Maximum program efficiency is achieved when activities are numbered in reverse order of the production process; that is, output for final demand is considered first, then the required output of intermediate products is considered, and so on.

  The aggregate production and consumption behavior of firms in a given sector is described by a production function. In the CFM the form or type of the function is activity-specific although the parameters may vary between regions to reflect technological differences. Firms within a region are treated as a group for two reasons. First, it would be infeasible to compute the likely behavior of every firm in the Nation. Second, data necessary to fit production functions are generally not available for individual firms.

  A production function relates the quantity of output, price of inputs, quantities and mix of inputs and the cost or price of output. In the CFM, it has been assumed that whatever quantity is desired by consumers will be produced by the sector. However, the quantity demanded depends upon price mechanisms as discussed in the next section.

  There are two fundamental types of production functions available to the analyst using the model: fixed input proportions functions and a wide range of variable substitution functions. Fixed proportion models are the most easy to estimate. Basically, the only information needed to be established are the ratio of labor inputs per unit of output commodity, the units of input materials per unit of output commodity, and so forth. Thus, when demand for a sector's commodity is given, the factors and individual materials required are solved directly.

  In many industries it is possible to interchange production factors. Consequently, functions may be employed to reflect the potential for substitution. The function itself only represents the range of factor mixes available to the sector. The factor mix actually chosen by the sector will depend on the prices of the factors and individual commodities. If the price of labor is relatively high, it would be expected that the firms in a sector would attempt to substitute material for labor where possible. Such an optimization problem may be stated simply as follows: minimize the cost of producing the demanded commodities, subject to the condition that demand is met. The CFM can operate with fixed coefficient functions, Cobb-Douglass functions, or constant elasticity of substitution functions.

- Sector Attributes: Once regions and activities have been specified, sectors may be defined. For each unique combination of region and activity, there exists a potential economic sector, the primary analytic unit of the CFM. Sectors are defined by a regional location for each activity. Several items must be specified for each sector. Each sector has initial prices for labor, capital and material, and may have unique production function parameters. Prices of labor and unit capital are set prior to any calculations and may be changed by a user at any point in simulated time. The price index of material is assumed to equal unity unless the sector uses more than one input commodity. In cases where the model must deal with one price for a mixture of commodities, the material price index is the sum of initial delivered material prices weighted by the production may be set by placing output constraints on specified sectors. In addition to achieving realistic levels of production, output constraints may reflect depletion of mineral reserves or environmental protection restrictions.

  Regionalizing the study area may be done by means of a variety of schemes depending on the expected application of the forecasts. A standard approach might be to use Bureau of Economic Administration (BEA) regions. However, other regionalizations may also be employed. States may be appropriate to simplify data requirements, or counties could be used if great detail were desired. Further, a mix of definitions may be used, such as BEA regions in the Mississippi and Ohio Valleys, and entire states on the Atlantic and Pacific Coasts, if interest lies mainly with economic activity near inland waterways.

  Regional size should be chosen carefully. Oversize regions can mask important flow patterns. On the other hand, excessively small regions can create estimation problems for the model, because available data must be allocated among very small areas.

- Sector Demand: Demand (commodity requirements) for each sector, divided into foreign export demand and domestic final demand, should be specified by the user. All demand is measured in physical units, such as tons or kilowatt hours, not monetary units.

  Foreign export demand is given externally to the model throughout simulation. Price elasticity of foreign demand must therefore be estimated by the user. Domestic demand needs only to be input by the user for the first year to allow first year forecasts. Domestic demand subsequent to the first year is estimated by the model and is assumed to be unitarily elastic with respect to price. The user may, however, override the estimated domestic demand with values based on alternative assumptions.

- Transportation Costs: Costs of shipping between all regions by commodity that may potentially exchange funds and commodities must be set. Data may be entered from the TFM or may be altered to any set of values. Omitted data will signal to the model user that a specific flow is feasible. The group numbers refer to individual commodities or groups of commodities.

- Commodity Flow Allocation: Input materials required for production by a sector are allocated to other sectors for production. The sector selection criterion is based on minimum delivered cost, which is the sum of FOB price in the producing sector plus transportation cost between regions.

- Consumption Computation: Wages paid by each sector contribute to the income of consumers in a region. Household income derived from distributed returns to capital is allocated to regions on the basis of per capita earned income. Regional income is then spent or converted to demand for commodities and services using an aggregate household consumption function.

- Personal Consumption and Regional Income: Data are required from a user to enable the model to estimate domestic demand relative to personal consumption patterns and the distribution of regional income. The proportion of income each individual is likely to spend on each commodity must be specified.

OUTPUT DATA PROVIDED

The CFM writes the following three major reports in addition to the playback reports of input data. In addition to the above three major reports, many other reports are also possible.

- Commodity Flow Report: This report is similar to the format of the flow data made available to the multimodal Transportation Freight Model. For each commodity, there is a list of flow volume between destination and origin. Commodities destined for export are noted with an F.

- Domestic Demand Report: For every region, data on wages, work force and income is reported, with the demand generated as a result of the income.

- Origin Flow Report: For each region, the region's market area for all outputs is displayed.

HARDWARE AND SOFTWARE REQUIREMENTS

The CFM has the following hardware and software requirements:

- o Line printer (131 columns)
- o Terminal (Input/Output) with modem, and on-line access to the Boeing Computer Services (BCS) Timesharing System
- o References and user manuals
- o Remote batch operations
- o SIMSCRIPT II.5 Compiler: The SIMSCRIPT II.5 program for the model is currently operational on the BCS system, but can be transferred with minor changes to any computer having a SIMSCRIPT II.5 compiler. The program was originally developed on the CDC CYBERNET system, and can still be used on this system with minor changes.

STRENGTHS

The CFM has the following strengths.

- o A major advantage of the multimodal network approach is its ability to handle the "new mode" problem, i.e., the revisions in modal shares accompanying the introduction of an entirely new transportation service (e.g., solids pipelines) or introduction of a mode into a market area which it did not serve previously. Modal choice models have difficulty here because valid parameter estimates for the new mode and revised estimates for the old modes are usually not available. When a multimodal network is used, this problem is resolved by simply inserting the appropriate links, nodes and supply functions into the network, and allowing the market dynamics built into the model to predict how shippers will react to the altered transportation environment.
- o In traditional modal choice models, multimode movements must be treated as a separate mode, which gives rise to parameter estimation problems and generally inhibits the usefulness of the model for analyzing alternatives designed to foster intermodal cooperation. A multimodal network model, on the other hand, deals with the intermodalism issue directly, and also yields estimates of the demand placed on intermodal transfer facilities.
- o The model gives planners and operations personnel a virtually complete picture of the national multimodal network.

- o The model provides for examination of the network loops of the feedback relationships of the integral components of the numerous physical systems.

- o The model can be used as a planning tool to assess and project the effects of future development contiguous to a waterway.

- o The model allows incorporation of changes in policy decisions into the model framework.

- o The model has great flexibility in its input and output requirements.

- o The model provides analysis of the interdependence among regions and industries.

- o The model works with and allows rapid changes in large and elaborate networks.

- o The model provides insights into operational consequences of development along a waterway.

- o Evaluation procedures are systematic and comprehensive.

- o The model allows system(s) to accept stochastic inputs and deterministic inputs.

- o The sums of regional outputs can be correlated with output from a national model.

- o The system is on-line and provides graphical interaction between the user and the computer.

WEAKNESSES OR LIMITATIONS OF USE

The CFM has the following weaknesses or limitations of use.

- o An objection sometimes raised is that excessive mode shifting occurs with the use of this approach. That is, very small cost savings for multimode (versus single-mode) routings will cause the model to predict en route mode changes which would not really occur. Although this can happen, proper modeling of the intermodal transfer facilities, with careful attention to capturing all of the relevant shipper costs, should minimize such difficulties.

- o The CFM does not by itself produce estimates of environmental impacts. The model does, however, produce traffic flow data which can be used by environmental analysts to estimate environmental impacts. Some types of impacts estimable via this means include air pollution, transportation noise, energy use and impacts on wildlife.

- Calculations are expensive if the full-scale model is run, and modifications of the basic model are time-consuming and costly. This problem is directly proportional to the data requirements.
- Calibration procedures are tedious.
- The minimum amount of data required for this type of model is considerable.
- Full-scale model uses very many data in which errors could occur in individual numbers and not be easily traced. This affects the reliability of the model predictions.
- Large scope and high level of aggregation of important parameters limits the application of this type of model to very broad planning only.
- Large variety of input options is an asset to an experienced user but a hindrance to a beginner.
- The model is not adaptable to small-scale computers.
- Not all evaluation criteria are well defined and easily measured.
- Growth strategies are internal to the model and cannot be changed exogenously.

MODEL TITLE: TRANSPORTATION FREIGHT MODEL

CODE NAME: TFM OR TFMODEL

WRITER:

CACI, Inc.
1815 North Fort Myer Drive
Arlington, Virginia 22209

Telephone Number: (703) 841-7800

PREVIOUS APPLICATIONS:

The first application of the model was the 1976 Office of the Chief of Engineers study entitled, "Potential Impacts of Selected Inland Waterway User Charges." A preprocessor routine was developed to simplify the use of the model with simulated networks (water and rail). The IBM version of the model was converted for use on CDC computers. Successive development, sponsored by the Transportation System Center (TSC) of the U.S. Department of Transportation, has augmented the TFM network simulation with highway and pipeline modes and an energy utilization accounting capability. Another applicaton of the TFM was a 1980 interagency coal export study (ICE) that was sponsored by the U.S. National Security Council.

LOCATION AND AVAILABILITY:

The model source code, model object code, and some sample data are stored on magnetic tapes at the Boeing Computer Services Company (BCS) in Bellvue, Washington. Corps personnel with a valid BCS account number may access the tapes on-line and make model runs on the BCS system. The serial numbers and characteristics of the tapes may be ascertained by contacting the Navigation Analysis Center. Other Corps personnel desiring to make model runs or access the tapes on-line or obtain copies of the tapes are also advised to contact the:

Navigation Analysis Center
Institute for Water Resources
U.S. Army Corps of Engineers
Casey Building
Fort Belvoir, Virginia 22060
Attn: Mr. Francis M. Sharp

Telephone Number: (703) 325-0574

DEVELOPMENT STATUS: Completed

DOCUMENTATION STATUS: Completed

MODEL OVERVIEW

The Transportation Freight Model (TFM) is an enhanced version of the Multimodal Network Program which was originally developed by the U.S. Army Corps of Engineers and subsequently enhanced by the U.S. Department of Transportation. The TFM is a multimodal commodity allocation model which allocates forecasts of commodity flows to the several transportation modes, based upon transportation cost and performance criteria. In terms of the Corps' responsibility for the Nation's inland waterway system, the basic reason for developing the Multimodal Network Model, now called the TFM, remains that of providing a device for evaluating, within a market context, the economic benefits obtainable from specified capital investments in any one or a combination of the following transportation modes: inland waterways, railroads, highways and pipelines. In such evaluations, the model considers all modes simultaneously in order to properly reflect important interactions among them. Due to the complexity of the included systems, the scope and purpose of the model are confined to evaluations of particular facility and network improvements that might be suggested. In accomplishing this function, however, the model indicates which portions of the various transportation modal networks are most susceptible to improvement in terms of potential benefits. This information is useful in studies directed toward determining gross allocations of transport investments across modes and suballocations within modes.

Capturing the costs and performance of the United States transportation system as it moves goods among regions is the principal task of the TFM. To accomplish this task, the TFM performs the following operations:

- o Defines the relevant system.
- o Generates a set of alternatives (plans, designs, operating policies).
- o Predicts the impacts of implementing each alternative.
- o Selects an alternative based upon an evaluation of the impacts.

Features and Aggregated Nature of the TFM

The large size of the networks to be simulated and the complexity of potential intermodal interactions dictated that the TFM be relatively aggregated in comparison with detailed modal simulators such as the Waterway Analysis Model (WAM). Networks are represented by line-haul links, nodes, access links and intermodal transfer links. The links and nodes are classified by performance characteristics. Link and node class performance is represented by fully allocated cost functions and capacity functions relating shipping time to volume. In keeping with the aggregation requirement, the TFM includes the following features:

Problem Size: The size of the problem which the model can handle is subject only to computer limitations. There are no inherent restrictions on the number of network elements or commodity shipments.

Transportation Networks: The TFM is represented as a set of connecting links and nodes. Links represent line-haul transportation facilities, and are described by the nodes at each end of the link, length, transport mode, capacity, and transit time and cost parameters. Nodes have attributes such as name, number, location (coordinates) mode, capacity, and time and cost parameters. A special class of links called "access links" represents local transportation and connect commodity origin-destination (OD) regions to the network. Another special link class represents intermodal transfer facilities and operations, and are used to stitch together the modal subnetworks into an integrated multimodal network. The specificity of networks is limited only by the computer resources available to operate the model. Normally, multiple links of an actual network for a mode must be represented by one link in the model network. The attributes of the aggregated link are weighted combinations of the attributes of the actual links.

Performance Functions: The operating characteristics of links and nodes are represented in abstract form as functions relating the cost of traversing a link or node to the amount of traffic which uses it. These costs are intended to be fully allocated costs, and hence, may not be equivalent to the transportation rates paid by shippers. (The model formulation is completely general; hence rates could be used if desired.) Similar functions called "capacity functions" relate transit time to shipment volume. Cost and capacity functions for intermodal transfers and for regional access are also used.

Transportation Equipment: The individual pieces of equipment on the networks are represented implicitly in the attributes (link and node performance functions) of the networks. Equipment configurations, such as tows, are represented only by their aggregate impact on cost or capacity relationships.

Commodity Movements: Commodity specific origin-destination shipment vectors are given. Each requirement for transportation is described by origin region, destination region, commodity type and tonnage. Optional specifications of historical or estimated modal split percentages and desired route from origin to destination are also permitted. Commodity types are defined by two-digit classification (e.g., Standard Transportation Commodity Classification or INSA Commodity Code) value and "inventory factor" or sensitivity to shipment time. Average value and inventory sensitivity are the commodity attributes used to simulate shippers' behavior with respect to shipment delay. Shipments are routed on mode/routes that would be perceived as a minimum cost-and-time path by shippers subject to the inertia effects of long-term contracting and the inertia of decision making due to institutional commitments. The circuitry of potential routes is constrained by elliptic allowances. The pattern of traffic is simulated from multiple starting conditions, and convergence tests are made to assess the stability of the final solution.

Shipment Routing: Least cost (from the shipper's viewpoint) routes from origin to destination are found for all shipments. Costs, both perceived and economic, are allowed to vary with shipment volume on each link. The least-cost route logic begins with the definition of the route cost. Route costs are a linear sum of shipping costs over each element in the route (nodes, line-haul links, access links and transfer links) and inventory cost (the product of inventory factor, commodity value and time required to traverse the route). Element costs and travel times are nonlinear functions of the quantity of traffic. Since the final quantity of traffic is not known until all shipments have selected routes, an initial volume estimate is required. In the event that final volumes simulated do not sufficiently agree with initial estimates, the model iterates until the final and initial estimates converge to an acceptable neighborhood of values. Selection of a minimum cost route by a shipment alters the volume travel time and the costs.

TFM PROGRAM STRUCTURE AND LOGIC

Overview of Operations Within Model

The TFM consists of a set of computer routines which may be functionally categorized as input routines, main analysis - routines, and output routines. The principal innovations in the model are its use of shipment-specific routing, the variety of useful path selection constraints employed, and the attention given to demand/supply dynamics and equilibrium. The main analysis-routines include algorithms for selecting routes through the multimodal network for particular commodity shipments, determining costs of such movements, assigning movements to particular routes in accordance with their relative costs, and collecting results of the allocations for presentation in output reports. The program begins by reading all of the input, with the exception of the shipments. Input data are stored into the various entities of the model, such as regions, nodes and links. A series of playback reports are then printed, with full cross-referencing among all the input data, providing a hard-copy record of the conditions under which the run was made.

The shipment data are now read and each shipment is allocated to the least-cost path from origin to destination. As the number of allowable routes between origin-destination pairs is potentially very large, route choice is constrained. Constraints which may be in effect for any or all shipments include route, mode, capacity, path circuitry, and inertia. A record of the path selected for each shipment is generated for use in subsequent operations. An optional equilibrium-seeking feedback loop, allowing for iteration of the shipment allocations to represent revised model selections by shippers, is also available.

After all shipments have been allocated to the network, the costs incurred by each shipment are computed using the node and link performance functions in conjunction with the total volume assigned to each node and link. A series of output reports and interface data files are then produced.

Major Computer Routines

The main operation of the model consists of several algorithmic processes that select paths and assign traffic. The minimal path algorithm finds that path from origin to destination which minimizes the sum of the costs incurred for traversing the nodes and links making up the path. Consistent with prevailing market theory, decentralized shipper decision making is assumed; that is, locally optimal paths (those which minimize costs from the individual shipper's viewpoint) are generated, rather than global optima (paths which minimize total system-wide cost). If all parts of the modeled market system were perfectly competitive, the aggregate result of individual decisions should converge toward a global optimum.

Major System Constraints

Path Constraints: Commodities may be restricted as to which modes of transportation they may utilize. Mode preferences may be specified so that a portion of shipments remains on a historically preferred mode. Element capacity-limits, which often exist on network bottlenecks, may be set and the involved volumes are never allowed to exceed a specified maximum (i.e., establishing upperbounds). Thus, links and nodes are sometimes limited to carrying flows below their capacities.

Circuitry Constraints: Route circuitry may be limited to a user-defined ellipse with foci at the origin and destination. To alleviate potential computational problems, a constraint is imposed on the number of routes considered in the path selection process. The location of each node is given in terms of geographic coordinates. An ellipse of given eccentricity is then constructed about the origin and destination regions for a particular commodity movement, with the major axis of the ellipse being the straight line connecting the centers of the two regions. The path selection algorithm then considers only those routes between the two regions that lie totally within the ellipse. The algorithm permits the ellipse to automatically increase in size, according to specified criteria, to insure that at least one route is included. In effect, this "inclusion ellipse" constitutes a circuitry constraint which greatly shortens the amount of computer processing time required; the price paid, of course, is that circuitous routes which may be less costly than the selected route are ignored.

Inertia Effect: An optional "inertia effect" is also included in the model, whereby a specified portion of any commodity shipment may be constrained to observe modal share percentages input by the user for that shipment. Least-cost paths for the mode-constrained tonnage are built using only nodes and links of the specified mode. The balance of the shipment is free to select the optimal route. This feature is needed to reflect the realities of long-term shipper contracts and other commitments, and to prevent oscillation in the model results in response to small intermodal cost differentials. Historical patterns may be reinforced by imposing inertia on the transportation patterns in a manner similar to establishing lower-bound constraints.

Assignment Algorithm: An iterative procedure is used to assign shipments to the network. For a base year case, link and node costs are initially set by entering the performance functions with flow volumes equal to each element's practical capacity (that flow volume for which delays are "normal") or some other user-supplied volume estimate. Selected routes may be fixed for shipments to simulate specific shipment requirements. Shipments with fixed routes are assigned by increasing the loadings on each link and node in the route by the shipment amount. Shipments with a fixed mode choice are assigned using the path selection routine with the additional constraint that all elements in the path must be of the selected mode. All other shipments are assigned using normal minimum path logic, and all costs are updated to correspond to the total assigned traffic. This entire process is repeated until the assumed and final volumes (and hence costs) agree within the specified tolerance. For succeeding time periods, volumes (and final costs) from one period are used as the initial volume estimates for the next period. After operation of the assignment algorithm, many types of output reports, with various levels of detail, are produced by the model. Many examples of the output reports are listed below, under the section on output provided.

INPUT DATA REQUIRED

The TFM requires two separate user-supplied input files: a transportation network file and a shipment file. The network file consists of region definitions, node and link descriptions, cost and capacity functions associated with traveling over each node and link, and a description of each type of commodity that is to be routed along the network. The shipment file consists of a list of shipments (interregional commodity flows) which are described by commodity code, origin, destination, volume in kilotons, and a specified route option if desired by a user.

Regions

Regions are functional economic-geographic areas which serve as sources and sinks of commodity flows. There must be one region card for each region. Regions are defined to the model by:

- Latitude - of the center of the region
- Longitude - of the center of the region
- Name - for reference. Eight characters will normally be printed on output reports. Additional spaces may be used on the form to further describe the region.

There is no unique data source for regions, as these must be defined with reference to the requirements of a particular model application. In general, the model user constructs an appropriate set of regions by studying planimetric, topographic, economic resource, transportation and other pertinent maps of the study area. INSA is oriented toward using the Bureau of Economic Analysis (BEA) regions.

Transportation Network

The TFM is made up of the following four types of network elements:

- Nodes
- Line-haul Links
- Access Links
- Transfer Links

Nodes: Nodes are link end points, and represent locations where links cross and traffic is permitted to switch from one link to another, where link characteristics change, and where other types of transportation facilities exist such as waterway locks. There must be one node card for each node in the network. Nodes are defined to the model by the following attributes:

- Latitude
- Longitude
- Mode - the transportation mode (water, rail, truck, pipeline) of the facility represented by the node.
- Node class - the class of facility represented by the node. Each class has associated with it two performance functions defining the operating characteristics of all nodes in the class.
- Capacity of the node in kilotons.
- Initial volume estimate - an estimate of the total traffic, in kilotons, passing through the node; used in conjunction with the node's performance functions.
- Name - for reference. Eight characters will normally be printed on output reports. Additional spaces may be used on the form to further describe the node.

Line-haul Links: There must be one access link card for each access link in the network. Transportation links between two nodes of the same mode are defined as follows:

- Length, in miles.
- A-node number - the node at one end of the line-haul link.
- B-node number - the node at the other end of the line-haul link.
- Line-haul link class - the class of line-haul transportation facility represented by the link. Each class has associated with it two performance functions defining the operating characteristics of all links in the class.
- Capacity (A to B) - capacity in kilotons of the link when traveling from A-node to B-node. Enter zero to prohibit travel in this direction.
- Initial volume estimate (A to B) in kilotons - used in conjunction with the link's performance functions.
- Capacity (B to A) in kilotons.
- Name - for reference. Eight characters will normally be printed on output reports. Additional spaces may be used on the form to further describe the node.

Transfer Links: Transfer links connect nodes of different modes and allow for intermodal transfers of commodity shipments. There must be one transfer link card for each transfer link in the network. Transfer links always represent single direction links. Line-haul links and access links can be designated as bidirectional (the normal case), or as single directional by setting the capacity to zero for one direction. They are defined as follows:

- o From-node number - the node on the inbound side of the transfer facility.
- o To-node number - the node on the outbound side of the transfer facility.
- o Transfer link class - each class has associated with it two performance functions defining the operating characteristics of all links in the class.
- o Capacity of the link in kilotons.
- o Initial volume estimate in kilotons - used in conjunction with the link's performance functions.
- o Name - for reference. Eight characters will normally be printed on output reports. Additional spaces may be used on the form to further describe the node.

Performance Functions

The operating characteristics of network elements are defined in terms of two types of performance functions — cost functions and capacity functions. As noted in the link and node data descriptions given above, these functions are specified for entire classes of facilities, rather than for individual network elements. There are four groups of class data, one group for each type of network element.

Facility Classes: All links and nodes belong to a class. Nodes belong to node classes and each link belongs either to a line-haul link class, an access link class, or a transfer link class, depending on the type of link. Each class points to a cost/capacity function pair. Classes are defined as follows:

- o Capacity function number - the capacity function to be used to relate transit time to volume level for all network elements in this class.
- o Cost function number - the cost function to be used to relate cost to volume level for all network elements in this class.
- o Two-way volume accumulation option - for line-haul link classes only. This feature considers the volume of traffic in both directions on a link when determining the shipping cost and time from the cost and capacity functions. Enter any nonzero number.

- o Name - for reference. Eight characters will normally be printed on output reports. Additional spaces may be used on the form to further describe the node.

Cost and Capacity Functions: The cost and capacity functions used to model network operations are provided as sets of coordinate pairs. In each case, the first coordinate (abcissa) represents either time (hours) or cost (dollars per kiloton) and the second coordinate (ordinate) represents volume of traffic (kilotons). For line-haul links, time and cost are specified on a per-mile basis. Linear interpolation and extrapolation are used for traffic volumes not directly represented by coordinate pairs. The functions are defined to the model as follows:

- o Number of time functions
- o Number of cost functions
- o Number of coordinate pairs
- o Volume (y-coordinate)
- o Time or cost (x-coordinate)

The reference number of each function, used to associate it with a facility class, is implicitly defined by the order in which the functions are input.

Commodity Data

The general characteristics of commodities to be shipped are defined in terms of a commodity classification scheme. There must be one commodity card for each commodity class. Input data for commodity classes are listed as follows:

- o Code - two-digit identification code.
- o Inventory Factor - reflects the economic importance of transit time to shippers of this commodity; specified as (% per hour)/100.
- o Value in dollars per kiloton.
- o Allowable modes - routes containing nodes of other modes will not be selected for shipment. Enter a nonblank character to allow the mode.
- o Name - for reference. Eight characters will normally be printed on output reports. Additional spaces may be used on the form to further describe the node.

Interregional commodity flows are input to the model as a list of shipments. The contents of each shipment record are listed as follows:

- o Commodity number
- o Origin region
- o Destination region
- o Volume of the shipment in kilotons
- o Trace Option - requests the model to print the path selected for this shipment. Enter any nonzero number.
- o Number of nodes in specified route - enter zero to not employ the specified route option.

If the specified route option is used, the following data element is required:

- o Specified nodes - the numbers of the nodes which made up the specified route for this shipment.

If the specified route option is not used, the following data elements may be input:

- o Inertia factor - fraction of total shipment which is to be restricted by mode as given below.
- o Modal split - fractions of the above shipment portion to be assigned to specific modes.

OUTPUT DATA PROVIDED

The output routines organize results of the model and present them in several types of reports. Included, in particular, are reports giving the allocations of movement requirements to the elements of the network and the costs associated with such allocations. Since the TFM is designed to interact with some of the other models described in this report, the output routines also provide data interface files. Interregional transportation costs are generated for use by the Commodity Flow Model, and origin node to destination node commodity traffic flows for given mode (such as port-to-port waterway traffic) are output for use by a modal simulation model (such as the Waterway Analysis Model).

The TFM simulates interregional freight transportation in sufficient detail to provide a wide range of statistical output data. The range of possible output reports, formats and included statistics for a complex model such as the TFM is almost limitless. The reports and data files described herein provide information which, in the view of the model designers, would be most useful to a transportation analyst or navigation planner. The model designer's ability to anticipate the user's output requirements is limited, and, in any case, these requirements are likely to change through time. The user should therefore be aware that the effort required to modify these outputs, or even to design new outputs, is in many cases not extensive. For current and complete information on the content and format of model outputs, the User's Manual should be consulted.

Playback Reports

As the first output function of the model, the input data are "played back" in convenient format as a series of reports. These playback reports show exactly how the data supplied by the user were interpreted by the program, which is very useful for detecting data errors; they also provide a hard-copy record of the conditions represented in a run of the model. The following nine reports are included:

- System Parameters
- Regions
- Nodes
- Line-haul Links
- Access Links
- Transfer Links
- Class Functions
- Commodities
- Shipments

Inclusion Ellipse

The playback reports are preceded by a cover page which displays an ellipse with the same eccentricity as that of the inclusion ellipse. Asterisks are printed at the foci of the ellipse, thus enabling the user to envision the approximate area of the network which is included in the minimum path calculations for any shipment. A similar page showing the backup ellipse is also printed.

Standard Output Reports

The statistics which will most likely be of interest to a transportation analyst are presented in four standard output reports as follows:

Path Traceback: For shipments with the "TRACE" option set, node names from destination back to origin are listed (for each iteration) when each such shipment is allocated to a path through the network. The commodity name, origin region name and destination region name are also listed. If the inertia factor is being used, the mode name and volume shipped via that mode are listed for each mode in the requested modal split.

Network Flow and Cost: For every link and node in the system, flow and cost data are computed from the last shipment allocation and output to the printer as follows:

- Flow - total volume in kilotons of all shipments using the link or node.
- Transit Time - in hours of all shipments using the link or node. Transit time is obtained from the link/node capacity function.
- Shipping Cost - per kiloton to use the link or node. The shipping cost is obtained from the link/node cost function.
- Inventory Cost - per kiloton to use the link or node. The inventory cost is computed as the product of the transit time, the inventory factor and the value of the commodity. Since many commodities may use a given link or node, the value reported here represents a weighted (by tonnage) average.
- Total Cost - per kiloton. Shipping cost plus inventory cost.

Network Flow and Cost Summary: This output report summarizes the data contained in the previous report. Summary statistics are provided for each mode of transportation, broken down by type of network element and by facility class. A separate table presents summary data for transfer links. Totals for the entire network appear in the last line of the report.

- Nodes: For each node class, the following data are printed:
  - Node Class - the number and name of the class.
  - Number - the total number of nodes in the class.
  - Percent Used - the percent of nodes in the class with nonzero flow.
  - Average Kilotons - total traffic allocated to nodes of this class divided by number of used nodes. Note that this statistic excludes nodes with zero flow.
  - Kiloton-days - product of transit time and shipment tonnage, summed over all nodes in the class. This statistic is an inventory-related measure of the quality of transportation services provided to shippers using nodes of this class.
  - Shipping Cost - product of shipping cost per kiloton and shipment tonnage, summed over all nodes in this class.

- Inventory Cost - product of inventory cost per kiloton and shipment tonnage, summed over all nodes in this class. This is also the product of kiloton-days, weighted average commodity value, and weighted average inventory factor, although the statistic is actually computed in the program in the manner defined above.

- Total Cost - sum of shipping cost and inventory cost.

o <u>Intramodal Links</u>: For each line-haul link class, the following summary statistics are provided:

- Link class - the number and name of the class.

- Number - the total number of links in the class.

- Total Miles - the total mileage of line-haul transportation facilities represented by links of this class. For two-way links, the mileage is counted only once, i.e., the mileage figure printed here is nondirectional. Any facility represented as two one-way links, however, will have its length included twice in the class mileage.

- Percent Used Miles - the percentage of total link miles in the class which carry nonzero flow.

- Average kilotons - weighted average traffic allocated to links of this class, <u>excluding</u> links with zero flow. Link flows are weighted by link length in computing this statistic to better reflect the spatial characteristics of average link traffic density.

- Kiloton-miles - product of link flow and link length, summed over all links in the class. (Note: The preceding statistic, average kilotons, is computed in the program by dividing kiloton-miles by total used miles.)

- Kiloton-days - product of link flow and transit time, summed over all links in the class.

- Line-haul Cost - shipping, inventory and total costs, as defined above for nodes, summed over all links in the class.

- Cost per kiloton-mile - line-haul cost (shipping, inventory and total) divided by total kiloton-miles.

o <u>Access Links</u>: The statistics printed for each class of access links are exactly the same as those printed for node classes and are defined in the same manner. It will be recalled that access links do not have a length attribute since they do not necessarily represent single physical facilities. Hence, they are treated similarly to nodes for output purposes.

o <u>Mode Totals</u>: Total flow and cost statistics for the mode are printed at the bottom of each modal summary report. The total kilotons shown are accumulated during the shipment allocation processing; this total is incremented by the amount of a particular shipment the first time that shipment accesses the mode. Hence, intermodal shipments appear in the total flow statistics for each mode used.

- Mode Transfers: A separate report giving flow and cost data for transfer links is printed as the last section of the network flow and cost summary. The entries in this report are defined in the same manner as those for nodes and access links.

- Network Totals: The last line of the summary report provides flow and cost totals for the entire network. The kiloton-total given here does not include any double counting.

Network Flow and Cost Summary, by Commodity: This is a second type of summary report included in the standard model output, which is organized on a commodity basis, and shows how traffic flows and costs were split among the various modes. For each commodity, and for the total over all commodities, the following data are provided:

- Commodity - name and two-digit commodity code.

- Mode - name of the mode for which traffic statistics are given in this line. A separate line, labeled "XFER," is provided to summarize intermodal shipments, if any. Hence, the totals shown for any single mode do not include that mode's share of intermodal traffic.

- Kilotons - the total quantity of the commodity allocated to this mode. The percentage of total commodity traffic which this flow represents follows immediately.

- Kiloton-miles - traffic flow (amount and percentage) allocated to this mode as measured on a ton-mileage basis.

- Kiloton-days - the amount and percentage of travel time and delay incurred by shipments of the commodity allocated to this mode.

- Line-haul Cost - shipping, inventory and total costs incurred for transporting the commodity by this mode.

The last line of the report displays totals of the above over all commodities and modes.

Interface Data Files

In addition to the printed outputs described above, the model also produces two interface data files. These interface files, intended for use as input to a modal simulation model and to a Commodity Flow Model, are described below.

Simulation Model Interface Data: The TFM outputs data which may be used as a partial input to a modal simulation model such as the WAM. The data elements of each record on the interface file are:

- Commodity code - two-digit code.
- Volume in kilotons of the shipment allocated to this mode.
- Beginning node name - first entry point of the shipment on this mode.
- Ending node name - last node of this mode for this route or route segment.

There may be one interface file for each mode if desired. The beginning and ending node name of each file record mark the boundaries of a route or route segment which is entirely composed of nodes of the specified mode. This file in essence is a mechanism for "tapping off" traffic data for input to a detailed modal simulator, such as port-to-port commodity flows for input to the inland navigation simulation model.

Commodity Flow Model Interface Data: For every shipment input to the TFM, there will be one or more (in the case of inertia modal splits) records output to the Commodity Flow Model interface file. These records provide the detailed commodity-specific interregional transportation costs needed by the Commodity Flow Model. Of course, they may also be used for other transportation analyses. Each record contains:

- Commodity code - two-digit code
- Volume in kilotons of the shipment or partial shipment
- Origin region number
- Destination region number
- Shipping cost per kiloton
- Inventory cost per kiloton.

HARDWARE AND SOFTWARE REQUIREMENTS

The TFM has the following hardware and software requirements:

- Line printer (131 columns)
- Terminal (Input/Output) with modem and on-line access to the Boeing Computer Services (BCS) Timesharing System
- References and user manuals
- Remote batch operations
- SIMSCRIPT II.5 Compiler: The SIMSCRIPT II.5 program for the model is currently operational on the BCS system, but can be transferred with minor changes to any computer having a SIMSCRIPT II.5 compiler. The program was originally developed on the CDC CYBERNET system, and can still be used on this system with minor changes.

STRENGTHS

The TFM has the following strengths.

- A major advantage of the multimodal network approach is its ability to handle the "new mode" problem, i.e., the revisions in modal shares accompanying the introduction of an entirely new transportation service (e.g., solids pipelines) or introduction of a mode into a market area which it did not serve previously. Modal choice models have difficulty here because valid parameter estimates for the new mode and revised estimates for the old modes are usually not available. When a multimodal network is used, this problem is resolved by simply inserting the appropriate links, nodes and supply functions into the network, and allowing the market dynamics built into the model to predict how shippers will react to the altered transportation environment.
- In traditional modal choice models, multimode movements must be treated as a separate mode, which gives rise to parameter estimation problems and generally inhibits the usefulness of the model for analyzing alternatives designed to foster intermodal cooperation. A multimodal network model, on the other hand, deals with the intermodalism issue directly, and also yields estimates of the demand placed on intermodal transfer facilities.
- Gives planners and operations personnel a virtually complete picture of the national multimodal network.
- Provides for examination of the network loops of the feedback relationships of the integral components of the numerous physical systems.

- The model can be used as a planning tool to assess and project the effects of future development contiguous to a waterway.

- Allows incorporation of changes in policy decisions into the model framework.

- Great flexibility of input and output requirements.

- Provides analysis of the interdependence among regions and industries.

- Works with and allows rapid changes in large and elaborate networks.

- Provides insights into operational consequences of development along a waterway.

- Evaluation procedures are systematic and comprehensive.

- Allows system(s) to accept stochastic inputs and deterministic inputs.

- Sum of regional outputs can be correlated with output from a national model.

- System is on-line and provides graphical interaction between the user and the computer.

WEAKNESSES OR LIMITATIONS OF USE

The TFM has the following weaknesses or limitations of use.

- One objection usually made to the use of the multimodal network approach is that this method tends to overemphasize transportation cost, to the exclusion of other variables affecting shipper decisions, i.e., shipments tend to be assigned exclusively to routes offering the lowest direct transportation charges, irrespective of specific commodity service needs. This difficulty can be overcome by defining link and node supply functions in a manner which recognizes commodity differences.

- An objection sometimes raised is that excessive mode shifting occurs with the use of this approach. That is, very small cost savings for multimode (versus single-mode) routings will cause the model to predict en route mode changes which would not really occur. Although this can happen, proper modeling of the intermodal transfer facilities, with careful attention to capturing all of the relevant shipper costs, should minimize such difficulties.

- The TFM does not by itself produce estimates of environmental impacts. The model does, however, produce traffic flow data which can be used by environmental analysts to estimate environmental impacts. Some types of impacts estimable via this means include air pollution, transportation noise, energy use and impacts on wildlife.

- Calculations are expensive if the full-scale model is run, and modifications of the basic model are time-consuming and costly. This problem is directly proportional to the data requirements.

- Calibration procedures are tedious.

- The minimum amount of data required for this type of model is considerable.

- Full-scale model uses very many data in which errors could occur in individual numbers and not be easily traced. This affects the reliability of the model predictions.

- Large scope and high level of aggregation of important parameters limits the application of this type of model to very broad planning only.

- Not adaptable to small-scale computers.

- Not all evaluation criteria are well defined and easily measured.

- Policy options are internal to the model.

- Policy (or growth) strategies are internal to the model.

- Substantial analysis is required to compile inputs.

- Input data requirement is an enormous quantity that could limit the usefulness of the model.

- Storage requirement is very large.

- Size and complexity of the program make it difficult to understand and apply.

- Large variety of input options is an asset to an experienced user but a hindrance to a beginner.

MODEL TITLE: TOW COST MODEL

CODE NAME: TCM or TCMODEL

WRITER: The Tow Cost Model is the result of the evolution of the INSA Flotilla Model which was originally developed by Dr. Anatoly Hochstein when he worked for CACI, Inc. The Transportation Systems Center, a unit of the U.S. Department of Transporation, modified the Flotilla Model to meet DOT requirements and changed its name to Tow Cost Model. The Huntington Engineer District made further modifications in the TCM while using it in the Gallipolis Lock and Dam Phase I Study. The current version of the Tow Cost Model has been documented by the Huntington District. Mr. David A. weekly, who was instrumental in the development of the documentation on the current version of TCM, may be contacted at the Huntington District by calling (304) 529-5499.

PREVIOUS APPLICATIONS: Gallipolis Lock & Dam Phase I Study (Ohio R. - Huntington Engr. District)

Lower Ohio River Navigation Study (L&D 52 & 53 Rehab.) (Louisville Engr. District)

Monongahela River Reconnaissance Study (Pittsburgh Engineer District)

LOCATION AND AVAILABILITY: The model source code, model object code, and some sample data are stored on magnetic tapes at the Boeing Computer Services Company (BCS) in Bellvue, Washington. Corps personnel with a valid BCS account number may access the tapes on-line and make model runs on the BCS system. The serial numbers and characteristics of the tapes may be ascertained by contacting the Navigation Analysis Center. Other Corps personnel desiring to make model runs or access the tapes on-line or obtain copies of the tapes are also advised to contact the:

Navigation Analysis Center
Institute for Water Resources
U.S. Army Corps of Engineers
Casey Building
Fort Belvoir, Virginia 22060
Attn: Mr. Francis M. Sharp

Telephone Number: (703) 325-0574

DEVELOPMENT STATUS: Completed

DOCUMENTATION STATUS: Completed

MODEL OVERVIEW

The Tow Cost Model (TCM), an enhanced version of the INSA Flotilla Model, operates on the supply side of the transportation demand/supply dichotomy. The TCM calculates the resources (fuel, number of barges and towboats, dollars) required to satisfy the demand for movement of cargo on inland waterways. The TCM makes its calculations by using a set of computer programs and detailed data that describes the waterway network, the equipment used for towing operations, and the commodity flow volume and pattern. The two principal computer programs contained in the TCM are the Resource Requirements Model and the TCM Postprocessor.

The TCM has been developed to operate on either a component of or on an entire regional waterway system. The TCM can be used to provide estimates of carrier costs for inland waterway transportation or to conduct system-wide economic impact analyses of major decisions related to the inland waterways. A TCM user can assess the economic impact of many and varied changes in costs, physical characteristics of a waterway system, and government policies by selecting alternative values of model input parameters.

Resource Requirements Model

The primary purpose of the TCM Resource Requirements Model is to determine the cost-effective fleet of towboats and barges required to move a given mix of commodities between a given pair of ports or a given set of port pairs (origins and destinations) on a waterway network of existing or assumed characteristics. Commodity flow (movement) requirements are provided to the model as origin-destination (OD) tonnages by season and by commodity class, with origin and destination ports being given by the network definition. The model also determines least-costs towboat and barge requirements on a system-wide basis. Any number of towboat and barge types, each with distinguishing operational or cost characteristics, can be accommodated by the model. Each of four, 3-month seasons is considered in the calculation of requirements because there are large seasonal variations in demand and operating conditions in some geographical areas. Equipment requirements are calculated for each season and for 1 year. Outputs include the required fleet mix and corresponding total costs and ton-mile costs at several levels of detail. At every level of detail, the number and types of barges and towboats are selected by the model on a least-cost basis.

The TCM Resource Requirements Model is an extension and refinement of the U.S. Army Corps of Engineers Waterway Flotilla Model, a component of the INSA program. The major extension of the Flotilla Model is the addition of the capability to incorporate a variety of user charge mechanisms and analyze their impacts. Other improvements include a number of refinements to the Port-to-Port Algorithm (see definition in glossary), more detailed commodity flow shipment reports, and the availability to redesign output reports and deal with dedicated tow traffic. Also, an additional tow lockage routine is now provided in the TCM.

The TCM Resource Requirements Model has been designed to be of particular value in studies of waterway user charges and their impacts on the towing industry operations and costs. The Model facilitates the analysis of cost-recovery mechanisms which could be implemented by means of government-imposed user charges. The user charges would be usually imposed to offset the government subsidization of inland waterways for cost items such as the following:

- Operations and maintenance of locks and channels
- Structure rehabilitation
- Navigation aids
- New construction

The model also provides the following four cost recovery mechanisms:

- Fuel tax
- Lockage fee
- Segment toll on a ton-mile basis
- Barge and towboat registration fees.

The TCM Resource Requirements Model calculates annual costs to the towing industry of owning, operating and maintaining the fleet. It can analyze and display costs for the entire system, for subregions of the system, for specific ports, locks and reaches, and for traffic between selected port pairs, dependent only upon study objectives and computer size constraints. Since the calculated fleet requirements and associated transportation costs are sensitive to the structural aspects of the inland waterway system, the model also provides assistance in evaluating alternative capital investment programs and in performing associated benefit/cost analyses. Varying input parameters will result in alternative fleet sizes and fleet costs, and provide a basis for economic analysis. The model may also be beneficial in analyses involved in specialized studies such as fleet distribution requirements in response to variations in seasonal demands or commodity mix, fleet composition changes as may be indicated by long-term trends in the economy, and studies of other exogenous influences.

TCM Postprocessor

The TCM Postprocessor computes tow costs and characteristics for commodity flows between port pairs. The primary sources of input to the program are the shipment file used by the TCM and the resource usage file which is an output of the TCM. The resource usage file, or trip file, contains a series of trip reports describing the costs and resources used for a tow between a particular port pair. Since the TCM determines optimal tow configurations at the transportation class level, each trip report describes a tow of aggregated shipments.

The TCM Postprocessor determines which shipments were aggregated to create each trip in the trip file. Information from the trip file and various system description data are then used to recalculate costs and tow characteristics at the commodity class level. The Postprocessor program will produce a shipment report which is the primary output of the program. The shipment report describes the costs of each shipment. It also shows ton-mile costs, costs per tonnage moved, and total costs for commodity movements between port pairs. Binary and printed outputs are available and are controlled by option switch settings and input data selected by the user. An optional listing of port and commodity names can also be printed.

Ultimately, on a system-wide basis, a TCM user can employ the TCM Resource Requirements Model and the TCM Postprocessor, together, to conduct impact assessments of situations such as the following:

- An investment in a new canal or river navigation project
- An investment in a replacement lock and dam project
- Alternative channel depths
- Changes in labor costs or fuel costs
- Government-imposed user charges
- Federal subsidies as reflected in waterway transportation costs

PROGRAM STRUCTURE AND LOGIC OF THE TCM RESOURCE REQUIREMENTS MODEL

First Phase

The first phase of the TCM methodology is the operation of the Resource Requirements Model for the purposes of reading, checking and storing the input data describing the waterway system. The system is represented as a network with ports, locks and river junctions as nodes and connecting waterway links between them. For computational purposes the network is partitioned into sectors which are linear, unbranched sets of links and nodes. In addition to the network data, the system description includes data on the types of towboats and barges available and cargo characteristics.

Second Phase

The second phase of the Resource Requirements Model reads the list of shipments to be processed. Each shipment is characterized by its origin and destination ports, type of commodity, season of shipment, tonnage, and, if applicable, portion carried by dedicated equipment. One of the functions of this phase is to aggregate the commodity flows by combining commodities having similar shipping characteristics (e.g., iron ore and coal). A working file containing the aggregated shipments is produced and saved for use in the fourth phase.

The shipments are aggregated by combining commodity classes into the smaller number of transportation classes defined by the user. Dedicated and nondedicated tonnages flowing in each direction are totaled and the average density and inventory cost of the aggregated shipments computed. The route between the ports under consideration is traced through the network using the routine table as well as the total tonnages flowing through each link and handled at each port of the network accumulated for future use. Tracing the path also reveals the minimum channel depth which, together with the average cargo density, will determine the barge loading factor used by the Port-to-Port Algorithm.

Third Phase

The third phase calculates a number of factors that are used in the fourth phase. The shipment tonnage totals produced by the second phase are used in the third phase to calculate the factors and tables required by the Port-to-Port Algorithm. Some of the factors and tables produced in the third phase are listed below:

- Empty barge factor for each link of the network.
- Seasonality factor for each link of the network.
- Towboat capacity factor on each link of the network.
- Annual average values for the maximum to size.
- Table of average tow speed for each towboat class, number of barges, and transportation class on each sector of the network. The speed table is used so that the somewhat lengthy speed calculations will not have to be repeated each time the Port-to-Port Algorithm is invoked.
- Average dock access delay for each cargo handling class by season.
- Average dock access delay for each cargo handling class by season by lock.

The final operation in the third phase is the production of data playback reports. These reports provide a printed record of the input data for each run and also include some of the tonnage totals and factors which have been calculated.

The heart of the operation of the Tow Cost Model occurs in the fourth phase, when the TCM uses the optimization Port-to-Port Algorithm to determine the least-cost way to ship cargo between the origin and destination of each selected pair of ports. The Port-to-Port Algorithm determines the time and cost required to ship cargo between a given pair of ports by means of a given type of towboat and a given type of barge.

Fourth Phase

In the fourth phase of the TCM, the Resource Requirements Model is ready to begin assigning towboats and barges to handle the shipments. The number of towboats and barges required for the shipments and the associated shipping costs are calculated in the fourth phase. The working file of shipments, aggregated by transportation class, is rewound and read to drive the fourth phase. For each new pair of ports read from the working file, the model's first action is to determine the shipping route between them. The route obtained from the routing table, is divided into sections called "segments" (not to be confused with the river segments defined by input data). Each segment begins and ends at designated fleeting points along the route. If the shipping route under consideration contains more than one segment, the optimization procedure must determine whether or not fleeting should actually take place at each fleeting point along the route. A particular choice as to which fleeting points along a route are and are not used is termed a "shipping plan." Each component of a shipping plan is called a "trip."

In order to select for each pair of ports the shipping plan having the lowest total cost, the model cycles through all possible shipping plans for each pair of ports. Evaluation of the total cost of a shipping plan involves selecting the most efficient towboat and tow size for each trip in the shipping plan. At this point, the towboat optimization procedure applies the Port-to-Port Algorithm separately to each trip to determine the cost of shipping cargo using each towboat class in turn. For each trip, the towboat class with the lower cost per ton-mile is selected. The costs of the trips in a shipping plan are summed to obtain the total shipping cost for the shipping plan. After the best shipping plan for each pair of ports has been determined, the equipment requirements of the best shipping plan are computed and recorded. However, the optimization procedure does not terminate at this juncture because the model makes an attempt to reduce the overall number of vessels (towboats and barges) through substitutions that more effectively balance the seasonal requirements.

During the fourth phase, in addition to the towboat and barge requirements, the Resource Requirements Model also records statistics on tow size distributions, port and lock utilization, and the costs associated with individual ports, locks and links of the network. If the appropriate option switches so specify, information about each trip is written by the Resource Requirements Model to the Resource Usage File for use by the TCM Postprocessor and/or is printed in the Least Cost Tow Characteristics Report. The Resource Usage File is a machine readable trip file which serves as the primary input to the Postprocessor component of the TCM. The TCM Postprocessor generates detailed reports on shipping operations and costs between selected pairs of ports. In the fifth phase of the operation of the TCM, the Resource Requirements Model also provides several summary reports which are listed in Table 1.

PROGRAM STRUCTURE AND LOGIC OF THE TCM POSTPROCESSOR

The TCM Postprocessor is a FORTRAN computer program consisting of a main program and three supporting subroutines. The main program reads in system description data and user input; reads trip reports sequentially; and calls the subroutines to read in shipments and/or locate shipments that contribute to trip reports for further processing.

TABLE 1
OUTPUT OF THE RESOURCE REQUIREMENTS MODEL

1. Annual Towboat Utilization and Costs Report
   - Number required by class
   - Percentage of time in use
   - Costs per towboat
   - Total costs by class
   - Ton-miles by class
   - Mills per ton-mile
   - Fuel used by class
   - Number required by season
   - Time distribution by function

2. Annual Barge Utilization and Costs Report
   - Number required by class (actual barges)
   - Percentage of time in use
   - Costs per barge
   - Total cost by class
   - Ton-miles by class
   - Mills per ton-mile
   - Number required by season
   - Time distribution by function

3. Tow Size Distribution Report
   - Distribution by towboat class
   - Distribution by towboat class by river segment

4. Annual Lock Utilization Report
   - Tonnage
   - Number of lockages
   - Number of tows
   - Number of barges (nominal barges)
   - Percent empty
   - Average lockage time (does not include delay)
   - Average delay time
   - Lockage-type distribution
   - Main chamber (percent tows)
   - Main chamber (percent utilization)

5. Lock Costs Report
   - Tonnage (repeated from Lock Utilization Report)
   - Cost by function
     - Lockage
     - Lock delay
   - Cost by source
     - Boat costs
     - Barge costs
     - Cargo costs
     - Lockage fees
     - Total costs

6. Annual Port Utilization Report
   - Kilotons shipped
   - Kilotons received
   - Number of barges loaded (nominal barges)
   - Number of barges unloaded (nominal barges)
   - Number of barges fleeted (nominal barges)
   - Number of tows served
   - Average wait for dock
   - Average wait for towboat

7. Port Costs Report
   - Summary of annual costs incurred at each port in the system

8. Segment Cost Summary Report
   - Summary of industry operating costs on each river segment
     - Total dollar costs
     - Costs per ton-mile

9. User Charge Summary Report
   - Government expenditures.
     - Operations
     - Maintenance
     - Rehabilitation
     - Project implementation
   - Industry operating costs (total dollar and mills per ton-mile)
     - Base cost (excluding user charges)
     - Costs due to fees
     - Base cost by river segment
     - Costs due to fees by river segment

10. Fuel Tax Analysis Report (total and by river segment)
    - Tax (specified tax level)
    - Gallons
    - Revenue (product of the two preceding values)
    - Target fuel tax revenue
    - Excess/deficit (difference between actual and target revenues)
    - Tax adjusted for full recovery (level required to meet target)

TABLE 1 (Continued)
OUTPUT OF THE RESOURCE REQUIREMENTS MODEL

11. Lockage Fee Analysis Report (total and by river segment)
    - Number of locks
    - Average lockage fee
    - Number of lockages
    - Revenue (product of the preceding two values)
    - Target lockage fee revenue
    - Excess/deficit (difference between actual and target revenues)
    - Average adjusted fee by segment (level required to meet target)
    - Industry costs (impact of the lockage fees—specified and adjusted)

12. Segment Fee Analysis Report (used to analyze a segment (ton-mile) toll)
    - Fee (mills per ton-mile)
    - Kiloton-miles (moved on the segment)
    - Target segment fee revenue
    - Excess/deficit (difference between actual and target revenues)
    - Fee adjusted for full recovery (level required to meet target)
    - Industry costs (impact of the segment fee--specified and adjusted)

13. Registration Fee Analysis Report (for towboats or barges or both) (total and by river segment)
    - Fee
    - Total horsepower or tonnage (basis for assessing)
    - Revenue (product of the preceding two values)
    - Target registration fee revenue
    - Excess/deficit (difference between actual and target revenues)
    - Fee adjusted for full recovery (level required to meet target)
    - Industry costs (impact of registration fee--specified and adjusted)

14. Least Cost Tow Characteristics Report (abbreviated)
    - Port A (first port number of the port pair)
    - Port B (second port number of the port pair)
    - Distance (one-way distance between ports A and B)
    - Transportation class (transportation class of cargo in the tow)
    - Kilotons shipped, A-to-B (annual cargo quantity)
    - Kilotons shipped, B-to-A (annual cargo quantity)
    - Round trips (annual number of round trip tows required)
    - Tow horsepower (towboat class selected by the model)
    - Number of barges (average number of nominal barges selected)
    - Utilization factors (see Users Manual)
        - Average fraction of the maximum towing capacity of the towboats in use
        - Average fraction of barge capacity that can be used due to channel depth restrictions and/or density cargo
        - Average fraction of barges (in the tow) which are loaded rather than empty backhauls
    - Mills per ton-mile
        - Total cost of shipping cargo between A and B, broken out by the seven activities considered by the model
    - Trip time
        - Time required (days) for a round trip for barges and for towboats

15. Least Cost Tow Characteristics Report (detailed)
    - All of the elements in the abbreviated form of the report are included in the detailed form of the report. However, in the detailed form of the report, trip time is broken down by activity and costs are broken down by activity and source. Then a final line provides four additional factors that are listed below:

        - Barge cost per day, variable - the average daily operating cost for barges in the tow. This is averaged over the different types of barges in the tow.
        - Barge cost per day, fixed - average fixed cost for barges converted to a fixed cost per day for barges.
        - Seasonality factor which is the ratio of cargo moved between A and B in the peak season to that moved in average season.
        - Cargo value - average cargo inventory cost expressed in dollars per kiloton per day.

The trip reports read in by the MAIN program contain data describing the optimal tow configuration and resource usage for shipments between a port pair. The data includes two port numbers, a transportation class number and tonnage moved in both directions. The shipment records read, in by one of the subroutines, contain a port pair, a commodity number and tonnage moved in one direction only. Each shipment records contributed tonnage to one of the trip reports. Shipments that contributed to a specific trip report can be found by locating all shipments with the same ports as those of the trip report and a commodity belonging to the transportation class of the trip report.

In the program, there are six common blocks of information which contain information that is accessible to MAIN and the appropriate subroutines. The common blocks and their associated data are as follows:

Common Block	Data in Block
PRINT	Run title, current line and page numbers, port and commodity names
FEES	Price of fuel, fuel tax, towboat and barge registration fees
BOATS	Barge and towboat characteristics read in from systems description data
COMDAT	Commodity characteristics, read in from the system description data
INPUTDA	Option switches, number of report requests, contents of each report request
TRIPDAT	All shipment data associated with a particular trip form the trip file

INPUT DATA REQUIRED FOR THE TCM RESOURCE REQUIREMENTS MODEL

The Resource Requirements Model requires three sets of user input data and optionally employs a fourth input file containing error messages. The four files are briefly described as follows:

- Run Setup Data: This file consists of three cards containing the run title, option switch settings and user fee specifications. It will normally be included directly in the run deck.

- System Description Data: This file contains records describing the waterway network, ports, locks, towboats and barge types, commodity characteristics and other such information.

- Commodity Flow Data: This file contains the port-to-port commodity flows to be processed by the model.

- Error Messages Data: This is a fixed file of input data on error messages supplied with the model. It may be omitted, in which case only error numbers (not messages) will be printed.

INPUT DATA REQUIRED FOR THE TCM POSTPROCESSOR

The TCM Postprocessor requires four sources of input. Three of these sources will be available if a parent run of the TCM has been completed. To make use of these three sources, TCM users need only make the files local to their jobs. A user is also required to set option switches, supply three system parameters, and include a list of shipment report requests. The three input files are briefly described as follows:

- System Description Data: This is the same file required as input to the Resource Requirements Model.
- Commodity Flow Data: This is the same file required as input to the Resource Requirements Model.
- Resource Usage File: See the description on this file under the section on Output Data Provided.

OUTPUT DATA PROVIDED

Playback Reports of the Resource Requirements Model

The first group of outputs produced by the TCM Resource Requirements Model is a set of "playback" reports which echo the input data used for a run. These reports also include the results of some of the model's preliminary calculations, such as the annual tonnages at ports and locks. The output reports are printed in the order in which most model computations are made. This helps in debugging when the program fails to run to completion.

Resource Usage File of the Resource Requirements Model

This file is generated by the TCM Resource Requirements Model and contains shipment information similar to that printed in the Least Cost Tow Characteristics Report. This file is intended to be used in the TCM Postprocessor Costing Program. Generation of the Resource Usage File is controlled by an option switch. The data elements of the Resource Usage File are listed in Table 2.

Result Reports of the Resource Requirements Model

The results of the TCM Resource Requirements Model computations are summarized in a series of output reports which are listed in Table 1.

TABLE 2

ELEMENTS OF THE RESOURCE USAGE FILE*

1. First port of port pair
2. Second port of port pair
3. First port of route segment
4. Second port of route segment
5. Transportation class
6. Towboat class used
7. Barge class used
8. Distance between ports
9. Kilotons shipped from first port to second port
10. Kilotons shipped from second port to first port
11. Number of round trips
12. Cargo load/unload time**
13. Wait for load/unload time**
14. Wait for towboat time**
15. Tow make/break time**
16. Travel on reaches time**
17. Lockage time**
18. Delay at locks**
19. Towboat capacity utilization
20. Minimum depth along route
21. Barge utilization factor, channel depth
22. Percentage of loaded backhauls
23. Seasonality factor
24. Cargo inventory cost
25. Number of barges in tow (for barge class used)
26. Segment fee recovery
27. Lockage fee recovery

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* The Resource Usage File is generated by the Resource Requirements Model and is used as input to other models.

** Time is in days/round trip.

TCM Postprocessor

The basic output of the TCM Postprocessor is the shipment report. Each shipment report contains data, as shown in Table 3, that describes a single shipment. Included in the data are the costs of moving a specific commodity from one port to another port, and the price of fuel as input in the system description data. When a commodity is moved in both directions between two ports, a shipment report is produced for each direction. Each printed shipment report contains the following information:

- Commodity type
- Port pair
- Distance between port pair
- Kilotons shipped and direction
- Cost per ton in dollars
- Total cost in thousands of dollars
- User fee costs as a percentage of total cost
- Lockage time in days for a round trip
- Lockage costs in thousands of dollars

The following mills per ton-mile costs are also printed:

- Barge costs
- Towboat costs
- Other costs (registration fees, taxes, segment tolls)
- Total mills per ton costs (including commodity holding costs)

TABLE 3

ELEMENTS OF TCM POSTPROCESSOR BINARY OUTPUT FILE*

1. Commodity number
2. Port number - first port
3. Port number - second port
4. Distance between ports
5. Kilotons flowing from first port to second port
6. Kilotons flowing from second port to first port
7. Cost per ton
8. Total cost
9. User fees as a percentage of total cost
10. Lockage time (includes delays
11. Lockage costs (includes delays)
12. Barge costs
13. Towboat costs
14. Commodity holding costs
15. Other costs
16. Total ton-mile costs
17. Percentage of loaded barges in backhauls
18. Number of fleeting points
19. Number of round trips required for flow in both directions
20. Barge time in days
21. Towboat time in delays
22. Computed tow capacity

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* The TCM Postprocessor Binary Cutput File is used as input to other models.

HARDWARE AND SOFTWARE REQUIREMENTS

The TCM has the following hardware and software requirements:

- FORTRAN IV Compiler: The FORTRAN IV program for the TCM Postprocessor was originally developed for CDC computers. With minor changes, however, the TCM Postprocessor program can be transferred to any computer having a FORTRAN IV compiler.
- Line printer (131 columns)
- Terminal (Input/Output) with modem and on-line access to the BCS Timesharing System
- References and user manuals
- SIMSCRIPT II.5 Compiler: The SIMSCRIPT II.5 program for the Resource Requirements Model is currently operational on the BCS system, but can be transferred, with minor changes, to any computer having a SIMSCRIPT II.5 compiler. The program was originally developed on the CDC CYBERNET system, and can still be used on this system with minor changes. Although, for operational facility the TCM Resource Requirements Model is written in SIMSCRIPT II.5, a user should bear in mind that the TCM is an optimization model, not a simulation model.

STRENGTHS

The TCM has the following strengths.

- Optimal tow configurations are determined at the "transportation class" level, whereas, in previous versions of this model (the Flotilla Model), transportation classes were aggregated to create each flow. The costs and characteristics of each transportation class flow are then used to create individual shipment reports that display statistics for a single commodity flow.
- The large selection of detailed data and types of reports provides a user with great flexibility in choice of analytical focus.
- Accounting framework for handling data and model outputs provides results that are internally consistent.
- Broad scope considers virtually all of the more important variables.
- There is extensive documentation on the calibration of the model(s).
- Gives planners and operations personnel a virtually complete picture of optimal costs.
- Provides for detailed comprehensive analysis of waterway transportation resource requirements.

- Data input is accomplished relatively easily.
- Provides for examination of the network loops of the feedback relationships of the integral components of the numerous physical systems.
- Frees planners to devote more time to general policy considerations.
- Great flexibility of input and output requirements and of computation techniques enables the program(s) to solve relatively simple problems with minimum effort or elaborate and complex problems with a high degree of accuracy/validity.
- Provides systematic and easy procedure(s) to determine policy impacts.
- Allows incorporation of changes in policy decisions into the model framework.
- Great flexibility of input and output requirements.
- Works with and allows rapid changes in large and elaborate networks.
- Planning and evaluation procedures are systematic and comprehensive.
- Allows system(s) to accept stochastic inputs and deterministic inputs.
- Sum of regional outputs can be correlated with output from a national model.
- System is on-line and provides graphical interaction between the user and the computer.
- The program(s) has a warning (red flags) system.

WEAKNESSES OR LIMITATIONS OF USE

The TCM has the following weaknesses or limitations of use.

- The TCM Postprocessor has been written in the FORTRAN IV programming language for CDC computers. The Postprocessor program does not have the extensive editing capabilities of the other TCM components which are written in the SIMSCRIPT II.5 programming language. As a result, the numeric data input procedures for the other TCM coponents are inapplicable to the TCM Postprocessor. Therefore, it is suggested that the TCM user make sure that the numeric data in the System Description Data File and the Commodity Flow Data File are right justified before the parent TCM run is made. By following this procedure, the user will avoid a potential source of error and be able to make full use of the two files without further modification.

- In the analysis of specific user charges or fees, it should be noted that the adjusted fees are only estimates, since changing user fee levels will generally change the optimal tow configurations selected by the model. Several iterations may be required to reach a state of equilibrium between the target fee and the adjusted fee. One exception to this is the ton-mile toll which will have no effect on system operations (bearing in mind that the TCM does not account for diversions of traffic to other modes).

- Environmental costs or opportunity costs for alternative uses of water resources are not considered in the TCM.

- Calibration procedures are tedious.

- Constant parameters (area, depth, velocity, etc.) are assumed to prevail in any one link.

- The minimum amount of data required for this type of model is considerable.

- Solutions are dependent upon the accuracy of the demand data.

- The approach requires substantial inputs of detailed data.

- Effective use of the many options requires much data input which can appear intricate until familiarity is established.

- Full-scale model uses very many data in which errors could occur in individual numbers and not be easily traced. This affects the reliability of the model predictions.

- More basic research is needed to refine the technique and analyze the sensitivity feedback relationships among the important variables.

- Large variety of input options is an asset to an experienced user but a hindrance to a beginner.

- Model can be applied only under steady-state conditions.

- Not adaptable to small-scale computers.

- Program is very large and can be very expensive if it is run with all options.

- Input data requirement is an enormous quantity that could limit the usefulness of the model.

- Substantial analysis is required to compile inputs.

- Storage requirement is very large.

MODEL TITLE: LOCK CAPACITY FUNCTION GENERATOR

CODE NAME: LOKCAP

WRITER:

CACI, Inc.
1815 North Fort Myer Drive
Arlington, Virginia 22209

Telephone Number: (703) 841-7800

PREVIOUS APPLICATIONS: LOKCAP was used in the National Waterways Study, prepared in 1982 for the Office of the Chief of Engineers, by the Institute for Water Resources, and in the Upper Mississippi River Basin Master Plan Study.

LOCATION AND AVAILABILITY: The model source code, model object code, and some sample data are stored on magnetic tapes at the Boeing Computer Services Company (BCS) in Bellevue, Washington. Corps personnel with a valid BCS account number may access the tapes on-line and make model runs on the BCS system. The serial numbers and characteristics of the tapes may be ascertained by contacting the Navigation Analysis Center. Other Corps personnel desiring to make model runs or access the tapes on-line or obtain copies of the tapes are also advised to contact the:

Navigation Analysis Center
Institute for Water Resources
U.S. Army Corps of Engineers
Casey Building
Fort Belvoir, Virginia 22060
Attn: Mr. Francis M. Sharp

Telephone Number: (703) 325-0574

DEVELOPMENT STATUS: Completed

DOCUMENTATION STATUS: Completed

MODEL OVERVIEW

The Lock Capacity Function Generator (LOKCAP) is a computer program that determines delay times through a double chamber lock. LOKCAP was originally developed to determine delay times at single chamber locks. The program computes the parameters of a hyperbolic function that returns the delay incurred by a tow in getting through a lock, as a function of the daily traffic volume that passes through the lock. Now LOKCAP has been designed to consider double chamber locks where the interference between chambers is explicitly taken into account in determining the parameters. For a given level of traffic volume, the delay can be computed if the daily capacity and the function parameter are known. The model determines the daily capacity of the lock (C_L) and a function parameter (D_L) such that the delay incurred is related to the daily traffic volume (Q) by the following formula:

$$\text{Delay} = \frac{D_L \cdot Q}{C_L - Q}$$

In a <u>single</u> chamber lock system, delay can be attributed to a number of factors including:

- o average service time
- o multiple cut requirements of certain tows
- o turnback or empty lock operations
- o tow inter-arrival times
- o recreational/lightboat lockages
- o maintenance and repair operations

In a <u>double</u> chamber lock system, all of these factors will affect delay at each of the two chambers. When the two chambers are relatively close together, there may be an additional component of delay time caused by interference among tows using different chambers. In particular, a tow beginning its approach to a chamber may be forced to wait until another tow has completed its exit from the other chamber. It should also be noted that the delay incurred may vary depending on which chamber is used. LOKCAP includes all of these considerations when calculating the lock capacity and function parameter for the lock delay function.

<u>Chamber Delay Functions</u>

LOKCAP proceeds by treating each chamber separately. A delay function is determined for each chamber with the effects of interference ignored. Briefly, the model determines the daily capacity of each chamber and a set of points on the delay curve. Each point represents a daily traffic volume and the delay as determined by the model at the associated traffic volume.

By varying the tow arrival rate (L), a set of points on the delay curve is generated. Variation of the arrival rate will also cause a change in the average service time. That is, service time is actually a function of the arrival rate. Since turnback operations are part of service time and the number of turnback operations depends on both the chamber operating policy and the number of tows waiting to be serviced, changes in the arrival rate will affect the expected service time. LOKCAP explicitly allows for this by recomputing the service time for each arrival rate.

Once the set of delay times and associated traffic volumes has been found, regression analysis is used to obtain the chamber delay parameter (D_c) for each chamber. Equation (a) can then be used to compute the delay at either chamber using the appropriate chamber parameter and chamber daily capacity (C_c). At this point, all effects of interference have been ignored. At the user's option an individual chamber report is available which displays information about each of the chambers.

Combining Delay Functions

Once the individual chamber delay functions have been determined, the effects of interference among chambers is introduced. A set of delay points (delay, traffic volume) has been collected for each chamber. Generally, the delays in one chamber set do not correspond to the delays computed for the other chamber. Using the inverse of formula (a), the model determines the daily traffic volume that would pass through the auxiliary chamber (or B chamber) at each of the delay times collected for the main chamber (or A chamber). If there were no interference, the lock traffic volume at the delay times collected for the main chamber would be the sum of the main chamber volume and the calculated auxiliary chamber traffic volume. The effects of interchamber interference will increase the delay times while holding the traffic volumes constant.

The probability of interference occurring will depend on the tow arrival rates at each of the chambers. Low arrival rates will produce minimal interference. For each of the delay times under consideration, the tow arrival rate which would cause the given delay is found. For the main chamber, this arrival rate is already available. The arrival rate is computed for the auxiliary chamber using the inverse of formula (c). These arrival rates can then be used to determine the probability of interference occurring. An interference time is then calculated for each chamber. Since interference occurs when a tow is approaching or exiting a chamber, the computed interference is actually a component of service time. LOKCAP adds the interference times to the service times that apply to the chamber arrival rates and recomputes the delay using formula (b). Since the arrival rates are unchanged, the daily traffic volume remains unchanged.

This analysis is performed at each of the delay times collected for the main chamber. The new delay times represent the delays incurred at the old main chamber traffic volumes and the calculated auxiliary chamber traffic volumes. The daily traffic volume through the lock at each delay time is the sum of the traffic volumes through the two chambers. In the final phase of this process, LOKCAP determines the daily lock capacity (C_L), the lock function parameter (D_L) and prints the lock report.

Applications

LOKCAP is not restricted to any particular type of lock. Since the individual chamber reports include the chamber capacity and the chamber delay function parameter, the program may be used for single chamber lock analysis. This is easily accomplished by supplying actual single chamber lock data for the A chamber and dummy data for the B chamber. The A chamber report results apply directly to the single chamber lock and the A chamber delay function may be used as the lock delay function.

Whether LOKCAP is used for a single or double chamber lock, there are a number of areas in which LOKCAP may be useful. These areas include:

- o Sensitivity of lock delays to changes in operating policies and/or tow distributions.
- o Sensitivity of chamber and lock capacities to changes in time devoted to rec/LB lockages and/or maintenance.
- o Effects of increasing exit times and approach times on delay.

LOKCAP PROGRAM STRUCTURE AND LOGIC

The LOKCAP is written in the SIMSCRIPT II.5 programming language for CDC computers. This section describes the overall program logic, the function of certain important SIMSCRIPT subroutines, and the various algorithms used to compute statistics and function parameters output by LOKCAP. The program logic of LOKCAP can be divided into two discrete sections. The first section determines the individual chamber functions and parameters. The second section performs the interference analysis and combines the chamber functions to determine the lock function. Each section will be discussed separately.

Chamber Logic

LOKCAP proceeds by treating each lock chamber as a discrete entity. The effects of interference among chambers are not considered until a delay function is determined for each chamber. Program control and flow during this phase of the procedure is controlled by the MAIN routine. Before working with the individual chambers, the MAIN routine reads in all of the input data and calls certain subroutines to perform some preliminary calculations such as the computation of the means and variances of the lockage component times. After all input has been read in, the distribution of tows at each chamber is determined.

When the above steps have been completed, the MAIN routine begins the individual chamber calculations. All of the procedures described in the rest of this section apply to each chamber. First the main chamber (or A chamber) statistics and parameters are collected, then the auxiliary chamber (or B chamber). Chamber processing begins with a call to routine COUNTER which determines how tows are to be locked through the chamber at various queue sizes.

INPUT DATA REQUIRED

LOKCAP does not require an extensive amount of input. All of the information required by LOKCAP is available through the U.S. Army Corps of Engineers Performance Monitoring System (PMS). For each chamber, data are needed to describe the expected time for each of the four phases of the lockage cycle. Tow type data are also required including the number and types of cuts needed for each tow type, the directional distribution of each tow type, and the frequency distribution of all tow types using the lock.

The following types of input data are required by LOKCAP:

- o Information about operating policies for the two chambers, the number of tow types and barge classes in the system, and certain global parameters. The operating policies define how tows are to be selected for lockage when there is a queue at both ends of the chamber.
- o Type of barge used in one or more of the tow types that transit the lock.
- o Name of lock
- o Name of river or sector
- o Type of tow that transits the lock.
- o Lockage cycle component times, setover operations, multicut operations, rec/LB time, and maintenance time for each chamber.

Lockage Cycle Component Times

LOKCAP recognizes four distinct components (phases) of the lockage cycle: approach, chamber entry, chambering, exit. The time required to complete each of these components may depend on the direction of the tow, the type of approach or exit and the individual chamber being used. In order to calculate both the mean and variance of each component time, two numbers are required. The user may input the upper and lower bounds for each component time (standard WAM format), in which case the mean and variance of the uniform distribution with the given bounds are calculated. Alternatively, the user may input the mean and standard deviation of each component time.

OUTPUT DATA PROVIDED

LOKCAP produces three types of output reports. Printing and control of all output is determined by the option switch settings supplied on the "O" input card (see discussion). Every page of output includes a heading which displays the river or river sector name and the lock name. An explanation and example of each report follows.

Echo Report

The first available output displays all user input in a labeled report. The first page of this report includes a playback of the barge class data, the tow type data, the number of delay points, the interference parameter and the type of lockage component times that are input.

The second and third pages of the echo report contain data describing the main and auxiliary chambers respectively. The operating policies, percentage of time for recreational/LB lockages, and annual down time are displayed. The report also includes the means and variances of each lockage component time as computed by LOKCAP. The report includes the mean and variance of each component and the total service time and variance for each of the eight cases, since there are eight types of single lockages that are possible, arising from combinations of direction, approach type, and exit type. The computed mean and variance of setover time and extra cut time are also displayed.

The last item of the chamber description section reflects the probabilities of lockage types by direction. For each lockage type that is used by a tow (single, setover, double, etc.) the probability of the lockage occurring at the chamber is printed for each direction. In the report, a cut number of "0" means a setover lockage.

Chamber Report

An individual chamber report is available which displays delay and capacity statistics for each chamber. Any interference effects which may occur among chambers is ignored in this report. For each delay point at which the analysis has been performed, the following items are printed:

- o Average inter-arrival time - the average number of minutes that elapse between tow arrivals at the chamber. This time is independent of direction.
- o Average time in queue - the average delay experienced by tows arriving at the given arrival rate. This delay, along with the daily traffic volume is used to determine the chamber function parameter.
- o Average queue size - the expected number of tows waiting at either side of the chamber for service.
- o Traffic volume - the number of tons that could pass through the chamber at the given arrival rate is displayed. Daily, quarterly and annual estimates are given.
- o Probabilities of approach/exit combinations - for each of the eight types of lockages that could occur, the associated probability of occurrence is printed, based on direction. The four upstream probabilities sum to one, as do the four downstream probabilities.

After each line of delay point information is printed, LOKCAP displays the traffic volumes and the probabilities that occur when the chamber is operating at capacity with a queue at both ends. Finally, the chamber delay function parameter and the daily chamber capacity are printed.

Lock Delay Report

The third type of output displays results applicable to the double chamber lock system. After allowing for the effects of interference among chambers, the following items are printed for each delay point included in the analysis:

- o Average delay at lock - an expected delay incurred by a tow that transits the lock. The delay applies to either chamber.
- o Daily traffic volume - the number of tons that could pass through the lock if tows experienced the given delay. Allowances for interference among chambers will increase delay while holding daily traffic volume constant.
- o Nominal barges - the number of standard size barges that could pass through the lock daily, given the delay.
- o Traffic intensity - this is a measure of lock capacity utilization. As traffic intensity approaches 1.0, the lock approaches 100 percent utilization of capacity.

The lock delay report concludes with a display of the lock delay function parameter and the daily capacity of the lock.

HARDWARE SOFTWARE REQUIREMENTS

The LOKCAP has the following hardware and software requirements:

- o Line printer (131 columns)
- o Terminal (Input/Output) with modem and on-line access to the BCS Timesharing System
- o References and user manuals
- o SIMSCRIPT II.5 Compiler: The SIMSCRIPT II.5 program for the LOKCAP is currently operational on the BCS system, but can be transferred with minor changes, to any computer having a SIMSCRIPT II.5 compiler.

STRENGTHS

The LOKCAP has the following strengths:

- o LOKCAP does not require an extensive amount of input. Data input is accomplished relatively easily. All of the information required by LOKCAP is available through the U.S. Army Corps of Engineers Performance Monitoring System (PMS).

- Allows incorporation of changes in policy decisions into the model framework.

- Allows system(s) to accept stochastic inputs and deterministic inputs.

- System is on-line and provides graphical interaction between the user and the computer.

WEAKNESSES OR LIMITATIONS OF USE

The LOKCAP has the following weaknesses or limitations of use:

- Each lock chamber is treated as a discrete entity. This approach results in the effects of interference among lock chambers not being considered until a delay function is determined (or input to the model) for each chamber.

- LOKCAP does not address systemic equilibrium analysis. More basic research is needed to refine LOKCAP so that it can be used to conduct simultaneous system-wide sensitivity analysis of the feedback relationships among the significant variables of systems which have many locks.

MODEL TITLE: WATERWAY ANALYSIS MODEL

CODE NAME: WAM or WAMODEL

WRITER: CACI, Inc.
1815 North Fort Myer Drive
Arlington, Virginia 22209
Telephone Number: (703) 841-7800

Dr. Larry Daggett, on the staff of the Corps Waterways Experiment Station at Vicksburg, Mississippi, and Mr. David A. Weekly, on the staff of the Huntington Engineer district, have extensively modified the WAM to enable the Mobile Engineer District to use WAM much more effectively. The modifications have simplified the WAM data requirements, made provisions for constricted channels such as bendways which require one-way traffic, and significantly enhanced WAM;s compatibility with the Tow Cost Model. The telephone number for Dr. Daggett is (601) 634-3111, and for Mr. Weekly is (304) 529-5499. Mr. Michael Irr, on the staff of the Pittsburgh Engineer District, is another knowledgeable WAM user who may be contacted by telephone at (412) 644-4169.

PREVIOUS APPLICATION: WAM has been used in several investigations conducted for the Office of the Chief of Engineers, by the staff of the OCE Inland Systems Analysis (INSA) Program, and in the analysis of the Gallipolis Locks and Dam Project.

LOCATION AND AVAILABILITY: The model source code, model object code, and some sample data are stored on magnetic tapes at the Boeing Computer Services Company (BCS) in Bellvue, Washington. Corps personnel with a valid BCS account number may access the tapes on-line and make model runs on the BCS system. The serial numbers and characteristics of the tapes may be ascertained by contacting the Navigation Analysis Center. Other Corps personnel desiring to make model runs or access the tapes on-line or obtain copies of the tapes are also advised to contact the:

Navigation Analysis Center
Institute for Water Resources
U.S. Army Corps of Engineers
Casey Building
Fort Belvoir, Virginia 22060
Attn: Mr. Francis M. Sharp

Telephone Number: (703) 325-0574

DEVELOPMENT STATUS: Completed

DOCUMENTATION STATUS: Completed

MODEL OVERVIEW

Purpose

The overriding purpose of the Waterway Analysis Model (WAM) is to represent on a computer the operation of the United States inland waterway system in moving waterborne commodity flows. The Waterway Analysis Model is also intended to be an evaluative tool for use in support of the Corps' planning and operations activities. Simulation of the system enables observation of its performance under a variety of assumptions about the economic and technical environment in which it would be operating. These performance predictions, in turn, are useful for assessing the adequacy of the existing system, and for estimating the economic benefits and environmental impacts of waterway improvements.

Within this broad purpose, the model is designed to support the following inland waterway management activities:

- Benefit Evaluation and allocation
- Long-range programming and capital budgeting
- Environmental impact analysis
- Analysis of navigation policy options
- Assessment of new inland marine technologies
- Interfacing with multimodal transportation planning
- Evaluation of lock and waterway operating procedures
- Preliminary screening of port capacity adjustments
- Forecasting future requirements for towing equipment
- Evaluation of towing industry performance

Features

While the WAM is a generalized model, it is also a relatively large and detailed simulator that provides explicit representations of individual waterway facilities, cargo consignments and vessels. The following digest of principal features indicates the model's scope, scale and level of detail.

- Problem Size: The size of problem which a model can handle is limited only by the computer resources available. There are no inherent restrictions on the number of ports, locks, river segments and tributaries, towboats, barges, types of towboats and barges or commodities. The model is specifically designed to accomodate systems as large as the entire Mississippi River-Gulf Coast waterway system.

- Waterways: The inland waterways are represented as a network of interconnected links and nodes. Contiguous link node groups are organized into sectors. Nodes represent the location of ports, locks, junction points and sector boundaries. Links represent river segments between nodes. The effects of specific channel conditions, such as bends or shoals, are normally represented implicitly by their constraining effects on navigation. Special channel conditions can, however, be explicitly represented.

- Locking: Each lockage facility is explicitly represented in the formof tow processing time distributions for each chamber. Processing time is broken down into approach, entry, chambering and exit times in a manner compatible with the Performance Monitoring System (PMS). An optional simplified lock representation scheme is also included. Single, setover, multiple-cut, multiple-vessel and open pass lockages are all accomodated. Both "first-come-first-served" and "N up-N down" lock queueing disciplines are available. Other waterway facilities, such as bridges, piers and navigation aids, are represented implicitly through their effects on tow size and speed. Again, these facilities can also be represented explicitly.

- Ports: Linear stretches of docks are combined and abstracted as a single point at which cargo originates and terminates. Port processing is represented by loading and unloading times and by barge pickup and dropoff times.

- Cargo: Commodity movements enter the model in the form of a list of individual shipments characterized by commodity type, origin port, destination port, tons and earliest possible departure time. This list is created by a separate interface program, which operates on a port-to-port origin-destination (O-D) tonnage matrix that is output by the INSA Commodity Flow Model (CFM), or on any other compatible cargo O-D matrix.

- Towboats and Barges: Individual towboats are explicitly represented and described by identification number, horsepower, size, maximum permissible flotilla size and sectors where they may operate. Barges in tow are represented as barge groups, consisting of one or more barges of common characteristics. All types of towboats and barges are permitted including dedicated equipment.

- Dispatching: Tow O-D movements through the waterway network are explicitly represented. Tow makeup (allocation of shipments to barges and barge groups to towboats) is internal to the model. En route dropoff and pickup of barges are permitted and fleeting operations are represented. Empty barge movements needed to accomodate trade imbalances are scheduled internally via decision rules built into the program.

- Recreational Craft: Recreation vessels are individually represented in terms of arrival at a lock for lock processing, but trip connectivity is not represented. Different weekend and weekday arrival rates may be specified.

Applications

Most applications will require multiple runs, with changes in the input data. Therefore, since the operation of the WAM is relatively expensive, an analyst considering using the WAM should be aware of the basic reasons for his study. Such awareness is also necessary in the formulation of study objectives. With a clear understanding of these objectives and a basic knowledge of the material presented in this report the applicability of the WAM to the study may become apparent. It may be necessary, however, to modify or redefine the basic study objectives at some later point, to more fully utilize the capabilities of the WAM. It was developed to estimate system reaction to the following types of system changes or modifications:

- o Lock capacity, resulting from different chamber sizes, different operating policies or varied equipment sizes; all resulting in new lockage times
- o River reach capacity, caused by altering channel depth and width, reducing or increasing restrictions such as bends and bridges or changing the number of locks in a reach
- o Travel times, affected by increase or decrease in delays
- o Equipment capacity and availability, resulting from changing towboat horsepower, barge cargo-carrying capacity or the number of towboats and barges available
- o System loading, such as increased or decreased amounts of cargo shipped

The system reactions of greatest interest are changes in delay times at locks, shifts in delay areas, and increases or decreases in equipment utilization.

After establishing the need to use the WAM simulation model, the user must determine the size and detail of the system to be modeled. Size, as used here, refers to both geographical boundaries and also the number of individual components (sectors, ports, locks, etc.) explicitly represented in the system. As has been previously implied, the more extensive the system becomes, the higher the cost of running the model in terms of computer resources. Simulation models are heavy users of computer time, and representational inefficiencies are magnified by the requirement to make a series of runs under varying conditions. In addition to the number of components represented in the system, model running costs are significantly affected by the level of detail required to simulate each component. In addition to cost, the following considerations are worthy of a user's attention.

Extent of Network: The system for a study area must include or account for every component of the total actual waterway network which interacts with the proposed study project. Each component may be either explicitly represented as individual locks, ports or reaches, or they may be implicitly represented by aggregate ports or as appropriate coefficients for reaches. In the actual network, each component represents a delay in the movement of the shipments. As long as the delay imposed by each component is somehow included in the input data, the model will simulate the actual waterway network.

Determining which components will be explicitly represented is the most critical task when establishing a system. These components, unlike implicitly represented components, require a significant amount of data collection and much more data input to the model, and hence, are more costly. Consequently, the user should keep the number of explicitly represented components to a minimum.

One method of selecting those components to be explicitly represented requires utilizing the origination-destination shipment list matrix to determine those areas in the navigation system which have little common tonnage with the study area. If the ratio of common tonnage versus total study area tonnage is very low (say 5 percent or less) for any area, then that area need not be explicitly represented in the model.

<u>Network Design</u>: The following is a suggested procedure for designing a WAM waterway network from scratch:

- o Sketch a large map of all waterways being considered as part of the system. The waterways must be connected.

- o On this sketch mark all ports and every river junction.

- o Also on this sketch, mark all locks to be included in the system.

- o Sector limits are then determined and delineated as follows: Between successive river junction ports or a system end point and a river junction port, at least one sector is formed. This sector may be divided into additional sectors if the river characteristics, which affect tow operations, change at some point within the sector. These additional sectors are defined by ports located where the river characteristics change. It is acceptable to have a sector boundary port (junction port) adjacent to an active shipping port. In practice however, a sector junction port normally coincides with the nearest active port.

- o Select the number of river systems desired and determine which sectors will be included in each. Every sector must be in a river system. Defining all sectors to be in one river system is acceptable; however the advantages relative to the presentation of output should be considered, since the output can be requested by river systems, limiting the printout reports to only areas of interest as opposed to getting output for the entire system.

- o Number each network element and assign a name to each river system, sector, port and lock.

<u>Fleet Size Considerations</u>: The only equipment operating the model system are towboats and barges. Towboats are divided into classes according to horsepower and/or size, while barges have classes that reflect the type and size.

The model is known to be sensitive to the amount of equipment which is input. Too many towboats result in the creation of too many small tows. An excess of barges leads to a dearth of empty barge movements. Too few towboats and barges constrains the system such that much of the cargo cannot be shipped during the simulation period. Therefore, it is important that the proper amount of equipment be supplied to the model during an analysis run. This proper amount must be determined during a calibration phase when the equipment amounts are adjusted and the model is run until satisfactory output is achieved.

Commodity Flow Considerations: Historical data on the commodity flows on the waterways are available from the Waterborne Commerce Statistics Center (WCSC). Future commodity flows must be obtained by making economic projections using methods commonly known to economists and planners. The data obtained, whether historical or future, will likely be annual flow information. The CFM and other programs have been developed to convert such data into shipments that WAM can accept as input.

WAM PROGRAM STRUCTURE AND LOGIC

The language of the model, SIMSCRIPT II.5, works on the assumption that the events to be modeled occur in a time sequence. It uses a PREAMBLE to set up the relationships between the events (things that happen), entities (things that are changed by an event), attributes (aspects of an entity) and sets (places to store entities when they are not involved in an event). The MAIN program, which is always the first subroutine to be executed, usually reads the data which define the system to be modeled and schedules one or more events. An event is scheduled by computing in advance how soon the event will take place and placing it in a pending events file. During the simulation when the clock reaches the time of the earliest pending event, it will process that event. Event Routines are individual miniprograms which are called by the system clock when the time comes to process that event. Almost all of the modeling logic is normally contained in these miniprograms or in other routines called by them. The WAM uses seven events as follows:

Event SHIP occurs when cargo arrives at a port ready for shipment.
Event CTRL occurs when the status of the simulation run is to be changed.
Event MOVE occurs when a towboat is moved.
Event BEGINEXIT occurs when a tow begins to exit a lock.
Event ENDLOCKAGE occurs when a tow completes it lockage.
Event RECARRIVAL occurs when a recreational craft arrives at a lock.
Event OPCHANGE occurs when the open pass status of a lock is changed.

The model views the navigation system to consist of a waterway network, equipment (towboats and barges), and cargoes. A network is made up of one or more river systems, each consisting of one or more sectors. A sector is made up of elements called links, each of which may be either a port, a lock or a reach. These links represent the physical waterway features with which tows directly interact. Sectors and river systems serve to organize these lower level elements into convenient units for processing analysis. A hierarchal representation of the waterway elements is depicted below:

Waterway Network (One or more River Systems)

- o Individual River System (one or more sectors):

  - Ports or Port Equivalents (a link in a sector)

  - Locks Which Contain Chambers (a link in a sector)

  - Reaches (a link in a sector)

- o Ports: On the inland waterway system, docks and associated port facilities are distributed along the rivers. There are far too many docks to represent individually in the simulation model, and since port operations are not of primary concern, these docks are grouped together and modeled as ports. Ports are located in such a manner that traffic through the locks and reaches of primary interest to waterway planners is closely approximated. There are two types of activity at a port: barge loading and unloading; and barge pickup and dropoff by towboats. These are represented through their average processing times which are input items. Note that each port is assumed to have an unlimited number of loading/unloading devices and therefore can handle any number of tows simultaneously. The individual barges within a tow, however, are processed one at a time by the same device at a given rate.

- o Locks: Locks are also treated as specific points in the network. The central abstraction employed is the representation of lock operations by random processing time distributions. The actual time required to lock a tow varies with a large number of factors including size and configuration of the tow, maneuverability, water level, current speed, presence of interfering traffic, weather conditions and pilot skill. Accounting for all such factors explicitly is infeasible, so a small subset of the most important ones are selected for explicit representation, and the influence of the remaining factors is treated by random selection from a probability distribution.

  An important facet of lock operations involves the queueing of vessels which cannot be passed immediately and the associated rules for determining the order of service, selection of chambers at multichamber lock facilities, etc. Once again, simplifications are required for computational feasibility. A queue is maintained for the lock facility and tows are assigned chambers as they became available.

- o Reaches: A reach is a section of waterway between two ports, two locks, or a port and a lock. It is the only network element with a nonzero length. The physical characteristics of actual reaches influence the traffic in two principal ways: through the time required to travel a reach, a function of its length and the tow speed attainable; and by limiting the size and draft, and hence, cargo capacity of tows. Both effects are represented in the model.

- o Equipment: The equipment in the model, consisting of towboats and barges, is moved from link to link according to the appropriate movement logic. Towboats are represented explicitly, with each vessel retaining its individual identity throughout the modeling period. Each class of towboat is described by its horsepower, dimensions, towing capacity and area of operation. It is possible to restrict the sectors in which the tows operate to simulate the observed practice of the towing industry to operate only in certain regions of the waterway.

Barge classes are described by their size and by the types and amounts of cargo they carry. The model uses this information and the depth along the route of shipment when simulating the loading of barges. If the barge cannot be loaded to its full draft, its capacity is reduced proportionally. The program represents barges not individually, but as a group of barges with identical characteristics and cargo to save computer memory. These groups are broken up and reassembled as necessary.

Tows share the waterways with other vessels, all of which are classified as recreational craft in the model. The model is not concerned with these vessels, *per se*, but only with their influence on commercial traffic. The most significant interaction occurs at locks, where they increase tow delays. This is the only place in the model where the existence of recreational traffic is considered. Recreational craft appear randomly, at a specified average rate, at locks where they wait for and complete their lockage and disappear from the system.

- Cargo: The transportation of cargo, is of course, the central purpose of the inland waterway system. Demands for cargo shipment provide the driving force for the simulation model, in response to which all other activity takes place. An input file of shipment demands is an event file called SHIP. Associated with each demand is a commodity type, amount (tonnage), origin, destination and time of availability. The many commodities transported in the actual system are aggregated by the model into commodity classes which may be flagged as hazardous to specify special handling when required. Each commodity class is assigned to a commodity group in accordance with its loading and unloading characteristics. The origins and destinations of shipments are the ports discussed earlier. Commodity flow data available to the user are generally in origin-destination matrix giving the total flows (by commodity) between pairs of ports over a period of time. A separate procedure is needed to convert such a matrix to the shipments needed by the model.

WAM Structure

The overall WAM structure and an elementary summary of how the model operates are presented below:

- Input From Tow Cost Model: WAM makes use of the Tow Cost Model (TCM) which is a separate model that estimates the size and composition of the vessel fleet needed to move the cargo specified in the shipment list. The TCM considers each origin-destination port pair sequentially, and derives least cost flotillas for accomplishing commodity movements between the pair, and for backhaul of empty barges. The results of all pairs are summed to produce estimates of vessel requirements, shipping times and costs, and tow size frequency distributions. First-cut estimates of the loadings upon waterway facilities are also provided, thereby allowing the model to be used for preliminary screening of potential waterway investments.

The TCM may be used on a stand-alone basis for many types of studies. Determining how the inland navigation fleet will evolve in response to commodity flow patterns and waterway system characteristics is a difficult task. Solution of this problem was the initial reason for developing the TCM. It soon became apparent that, because the fleet makeup was to be sensitive to tow operating costs, the model could also be used for first-order estimates of total waterway operating costs for alternative system configurations. Thus, the TCM was developed with both of these uses in mind. The TCM is described in greater detail in another section of this report.

- Input Processing: This portion of the WAM program reads the input data from input forms, edits the data for completeness and consistency, prints appropriate error messages when indicated, and translates the data into the forms needed by the simulator. Playback reports are also printed, providing for future reference a hard-copy record of the conditions simulated.

- Initialization: The initialization segment of the WAM program starts up the simulation. The available stock of towboats and barges is distributed throughout the system in proportion to shipping requirements.

- Cargo Arrival: Cargo arrival is an exogenous event which drives the model. Arriving cargo is filed into a backlog queue at the origin port. Empty barges are located at the port and loaded, considering both barge capacity and en route depth restrictions. Arriving cargo may also initiate empty barge movements from other ports if empties are not available at the origin port.

- Tow makeup: Groups of barges with compatible destinations are assigned to a towboat up to its pushing capacity. When that limit is reached or when no additional barges are available. the tow is dispatched from the port. Dedicated movements are handled by checking for matching "flags" on the cargo, barges and towboat.

- Routing: Anytime that a tow arrives at a sector junction point, routing tables are consulted to determine the tow's next sector and travel direction. For situations involving alternative routing possibilities, the route may be specified in the input data. As a default option, the route offering the shortest travel time will be selected.

- Tow Movement: A speed function, sensitive to both tow and channel characteristics, is used to determine the tow's travel time from one node to the next. Port processing, locking and fleeting may occur at various nodes.

- Port Operations: A tow may stop at a port to drop off barges destined there, or to pick upO barges with destinations compatible with the tow's present destination. Barges delivered are unloaded, and then immediately reloaded with commodities awaiting shipment, or else added to the port's stock of empties. Empty barges may be dispatched to other ports with equipment deficits. If so, they are placed in the port's set of barges available for pickup, and handled the same as loaded barges. If a towboat drops off all of its barges, it picks up available barges at the port, or else is dispatched as a light boat to the nearest port which needs it. Light boats may also await the availability of barges at their current location if this would be advantageous.

- Lock Operations: Tows arriving at a lock are served immediately if the lock is idle, or are given a place in a queue. Tows are selected for service on the basis of the queue discipline in effect at the lock. the lockage type required is determined by comparing the tow size and the chamber size. Random draws are made to establish the times for each appropriate locking time component. If the lock has more than one chamber, a tow is assigned to the main chamber if available, or else to an auxiliary if the tow can be processed as a straight single lockage. Recreational craft are made to appear at the lock by a separate random generator, are maintained in their own queue, and compete with tows for service according to normal Corps operating policy.

- Junction Operations: Towboats may be restricted to operation on selected sectors of the waterway network. When a tow reaches a junction point beyond which the boat cannot proceed, it will drop off its barges for subsequent pick up by another boat, and may pick up barges awaiting a tow traveling in the other direction. With respect to such fleeting operations, junctions are treated as ports. Tow size may also be restricted by sector, giving rise to additional fleeting. Barges discarded to reduce tow size are dropped on a "majority rules" basis (barges with a common destination are retained).

- Output Processing: Many types of output reports, with various levels of detail, are produced by the model at the user's option. Standard outputs are as follows:

  - Lock statistics, by direction of travel

    - -- number of tows
    - -- cargo tonnage
    - -- number of barges
    - -- number of light boats and recreational craft
    - -- lock utilization
    - -- number of chamber operations
    - -- average delay per tow
    - -- maximum tow delay
    - -- average maximum queue lengths
    - -- average and maximum queue lengths

- Towboat utilization, by towboat class

  -- number available
  -- average time spent en route, delayed en route, loading and unloading and idle
  -- average tow size
  -- total ton-miles

- Port activity, by port and commodity group

  -- tons originated, loaded, shipped and received
  -- barges loaded, dispatched and received
  -- average wait for barges and towboats
  -- number of tows stopping

- Reach traffic

  -- number of tows
  -- number of barges
  -- number of light boats
  -- tons and ton-miles
  -- average tow speed

An optional simulation trace feature is also available. The user may request traces of all activity associated with specified shipments, towboats or facilities. A trace is too detailed for normal use, but it provides insight into model operations. also, copying trace output to tape for subsequent analysis by a postprocessor program serves as a comparatively easy means of producing special output reports.

Simulation

Although the PREAMBLE defines the entity, set, attribute, event relationships which are the foundation of the model, the MAIN program sets the values of those variables to conform to a particular system being modeled. It does this by reading an extensive set of system data which create within the computer a mathematical abstraction of the system being modeled. For example, the PREAMBLE defines the relationship between locks, queues, tows and barges, but it is the system data read by the MAIN program which determine the number of locks, tows and barges and their sizes, capacities, locking characteristics, etc. This information changes from system to system. The task of determining the values of these parameters and setting them up in a system input data file is referred to as "configuring the model." The MAIN program also distributes barges and towboats throughout the ports in the system in proportion to the origins of the shipments at the beginning of the shipment file, schedules a MOVE for each tow in the system and starts the simulation.

System Clock

The system clock is an automatic feature in the SIMSCRIPT II.5 language and plays a very important though unobtrusive part in the simulation. It determines which event is to be executed next and it is the source for all the time calculations in the model. When the clock is used to compute time, it is directly accessed by the code using the variable TIME.V. Elapsed time is computed by recording the difference between the value of TIME.V at the beginning and end of an event.

The operational logic of the model can be described in four major categories: cargo arrival, empty barge location, barge loading, unloading and dispatching; and tow movements.

- Cargo Arrival: The activity of the simulated system begins when cargo arrives at a port for shipment to another port. The information for this shipment is contained in the external event file SHIP. The shipment occurs automatically when the system clock reaches the time specified for the shipment to enter the system. This cargo may be divided and moved in a number of different tows, but it is still considered a single shipment. A record describing the shipment is kept in a set of such records maintained at the origin port. This record exists until the entire shipment has been delivered to its destination, at which time the record is no longer of interest and is destroyed.

- Empty Barge Location: The first step in moving a shipment to its destination is obtaining empty barges to carry it. Every port in the network maintains a set of currently available empty barges. The barges available at the shipment origin port are checked first, and as suitable barges are located they are assigned to the shipment with loading beginning immediately. If sufficient empty barges are not available at the origin port, a search of the other ports is begun to locate the nearest source of suitable barges. Barges located in this manner must be brought to the shipment origin port before they can be used. Every port maintains a set of barges awaiting movement, both loaded and empty. As empty barges are located, they are tagged with the location of the shipment origin, which now becomes the barge destination, and transferred to the set of barges awaiting movement at the port. They wait here until a towboat arrives at the port and picks them up for movement to their destination. If no barges are found in any ports in the network, a record of the deficiency is placed on a special list which is examined whenever barges become available.

- Barge Loading, Unloading and Dispatching: Barges are loaded with the cargo when suitable empty barges become available. The key computation is the capacity of each barge. A maximum capacity is defined in the input data, but it may be necessary to reduce this figure because inadequate depth along the shipping route limits the usable draft of the barges. Once the capacity is known, the amount of cargo that can be loaded on the available barges and the number of barges required to load the available cargo is determined. The time required to load the barges is calculated according to the loading rate for the port and commodity type involved. Note that the barge operations take place quite independently of towboat movements. What has essentially been accomplished is the conversion of cargo flow requirements into requirements for movement of barges, both loaded and empty. The next step is to introduce the towboats through which these movements are accomplished.

- Tow Movements: The movement of towboats through the waterway network is the heart of the simulation model. The basic mechanism involved is a simple process of advancing a location indicator associated with each towboat from one link (port, lock or reach) of the network to the next. The type of new link is then determined and the appropriate processing is selected. This processing generally involves a delay in simulated time, following which, the process is repeated. There is no central scheduling mechanism for towboats in the model. Rather, destination are determined in a localized fashion by the barges which a towboat picks up. When an initially unassigned towboat picks up a group of barges, its destination becomes the same as the barges. En route to this port it may, if capacity permits, pick up additional barges with compatible destinations, possibly extending the planned trip. If all barges are dropped off at a port, a new set may be taken on and a new destination thereby determined.

The basic activity of a towboat at a port is the delivery and pickup of barges. Upon arrival at a port, the first activity is the delivery of any barges destined there. The only effect such a delivery has on the rest of the tow is the delay involved in dropping the barges off. The possibility of picking up new barges is now considered. Two conditions must be met before a group of barges can be added to a tow: the total tow size must remain within the limits in effect; and the destination of the new barges must be compatible with the established route of the tow. It is possible that a towboat will drop off all its barges at a port and then find nothing to pick up. At this point, the towboat can wait at the current port for barges to become available, or it can travel empty, as a light boat, to another port where barges are currently available.

A junction is a boundary port between two sectors in the simulated network. It is convenient to define network end points as junctions as well; then every sector begins and ends at a junction. As noted previously a port must be located at every junction. Hence, all port operations described in the previous section also take place at junctions. A tow traveling from one sector to another requires additional processing to (a) perform a routing choice, (b) examine the possibility that different groups of barges in the tow may need to go different directions, (c) consider a possible change in the tow size due to restrictions on the new sector, and (d) determine if the towboat is unable to proceed due to operating area restrictions. The net effect of any of these conditions is to drop off or pick up barges and to pick a new destination for the tow.

When the tow arrives at a lock, one of two relatively independent operations occur: queuing, with its associated priority and chamber usage logic; and the actual passage of vessels through the lock. The model determines whether a chamber is available for immediate use and whether an available auxiliary chamber should be used. If a suitable chamber is available, lockage begins immediately; if not, the tow joins a queue of vessels waiting to use the lock. Eventually a chamber will become available, and the tow will be removed from the queue to start its lockage. The lockage logic is critical to our analysis and quite technical. Basically, the length of time for a tow to pass a lock is determined from random time distributions which are described in the input data. This accounts for the variable lengths of time different tows take to pass the same lock due to many changeable conditions. The variable lockage time is the principal contributor to the randomness of the WAM.

The transit of a network reach between two ports, two locks or a port and a lock, is represented in the simulation by a delay in simulation time. The only processing associated with this is the computation of the tow speed and thereby the time required. An empirical formula relating resistance to vessel dimensions and current barge loading determines the resistance of each tow. The tow resistance and the towboat horsepower determine, through a force equilibrium condition, the tow speed achievable in still water of unlimited depth. This speed is reduced by restricted channel dimensions and the current speed is either added or subtracted as appropriate.

AVOIDING AND ANALYZING ERRORS AND PREMATURE TERMINATIONS

Warm-up Period: The warm-up period of a model allows the model to run until it reaches a steady state. The initialization process of the WAM is intended to minimize the required warm-up time. This warm-up period, however, must be determined by the user of a model.

Certain parameters are considered as key parameters because they describe the most critical elements of waterway operations. A user of WAM should note that it is unlikely that all of the key parameters will stabilize simultaneously. If the initial problems and inaccuracies in the input data are such that they cause difficulties in reaching system stability, it may be necessary to proceed iteratively without the warm-up determenation and the calibration. The key parameters are listed below:

- Number of Barges Per Tow: This is an indicator of the average tow size on a sector.
- Chamber Utilization: This gives the percent of time a lock chamber is in use.
- Percent Loaded Barges: This indicates the distribution of barges and whether enough barges are available.
- Lockage Service Time: This reflects the many factors that determine lockage times.

Calibration: After establishing an appropriate warm-up period, the calibration of the model must be undertaken. The purpose of a calibration is to demonstrate that a simulation model does actually simulate a system's performance.

Two types of model calibrations are worthy of mention. The first type is the initial calibration where the acceptance or rejection of the model is at stake. This type of calibration is often referred to as the validation of a model. The second type is the recalibration of a model. Recalibration of a simulation model should be performed after each major change in the system being simulated by the model. The calibration of a simulation model is essential in making meaningful use of the model. Otherwise, failure to validate a simulation model can often lead to acceptance of incorrect data and to the drawing of embarrassingly wrong conclusions.

In general, calibration is accomplished by manipulating input data and making model runs in an iterative manner until all originating tonnage is shipped to its destination and key model output parameters converge to an acceptable range of values. Some of the major input parameters which influence activities (operations) are listed below and described at greater length in the glossary:

- Amount of Total Equipment: The number of towboats affects tow size and the number of barges influences the percent of empty barges moving in tows.

- Amount of Dedicated Equipment: Allocating a certain number of towboats and barges to be used only for delivering one or more specified shipments is a powerful control.

- Sector Designation by Towboat Class: Another useful regulator of certain model activities is the required designation of the sectors on which each towboat class is allowed to operate.

- Shuttle-Institution: The sector designation control can be used to institute shuttles whereby towboats operating only on a tributary could transport commodities in small tows to and/or from a mainstream, where they would be picked up and/or dropped off by larger tows.

- Barge Class Definition by Commodity Class: Defining (and restricting) the commodity classes that are allowed to travel in each barge class is another required input.

- Tow Size Designation by Sector: A degree of control over tow sizes can be achieved by designating the maximum tow size for each sector.

- Other Input Parameters: There are other input parameters, called "knobs," that influence model activities. These knobs are not obtained by observation and/or measurement of real-world conditions. Knobs are described at greater length in the glossary.

Avoidance of Errors by Use of the Input Data Checklist: Because of the complexity of the WAM and its required input, making some errors when submitting numerous model runs is unavoidable. However, a way to avoid repeating some errors and to avoid making some errors even the first time is to prepare a checklist of items which should be checked prior to every run submission. These items are things to watch for based on previous errors or on anticipation of possible errors. New items should be added to the list ad found necessary.

The checklist developed during the calibration efforts of the Pittsburgh District appears in the WAM User's Manual. The items listed represent problems which could lead to premature run termination or incorrect output and would not be caught by the data checking feature of the model. some are control card problems and are only applicable if the model is being run on the BCS.

Errors Detected by the WAM Program: Errors occurring during execution of the WAM are classified by whether they are detected by the program or by the processing system. Errors in the first category, which occur during the initial data phase of a run, are flagged by an error message that is normally printed following the image of the erroneous card in the input data listing. If the listing has been suppressed, cards with errors will still be printed. All errors normally detected by the program can be eliminated prior to a simulation by making a separate data checking run with the simulation suppression switch turned on, and with the limits of allowable input errors and allowable simulation errors set to the maximums. Whenever more than a few changes are made to any of the input, a user is strongly encouraged to make a data checking run.

Errors Detected by the SIMSCRIPT Processing System: Errors detected by the processing system are independent of the program and will always cause a run termination. Exceeding job resource limits such as the central processing time limit, the central memory word limit or the print limit will cause such a termination. Normally, however, a system-detected error will be flagged as one of eight types of mode errors, which basically are attempts to reference or use nonexistent, infinite or indefinite variables. (An indefinite variable is produced by dividing 0 by 0 or multiplying an infinite number by 0).

Correcting mode errors is not straightforward because there is no precise indication as to the exact source of the problem. A "traceback" listing is usually provided on the BCS whenever a mode error occurs. This enables the user to determine the routine that was in control when the error occurred. Often that clue is enough to help locate an error in the input data. Another source of clues for correcting mode errors is the status file created whenever an error termination occurs. It completely describes the system at the exact time of termination and a careful analysis of the number can lead to the source of the problem.

Errors which cause premature termination late in a long run are especially costly because the relatively high expense of the simulation up to the termination time is lost. The likely cause is an error on one of the late-in-time external event input cards (CTRL or SHIP) which are not read until the simulation time clock advances to the time on the card. The chances of this situation occurring are greatly reduced if a data check run is made prior to the simulation run.

INPUT DATA REQUIRED

The WAM requires three input data files to run. These files are:

- System Description Data - describe the waterway network, the vessels using it, the commodities transported, and other aspects of the system to be simulated.

- Shipment Data - a list of commodity flows (shipments) to be moved by the system. These data effectively "drive" the model.

- o Run Control Data - control the run length, statistics collection, output production, and other related aspects of the simulation run.

The above three files are described in greater detail below.

System Description Data File

"A" Input Records - Array Dimensions and Miscellaneous Parameters: "A" data consists of two cards specifying the numbers of certain system entities and values for certain miscellaneous parameters. These cards must be the first two cards in the input deck (with the exception of comment cards which may appear anywhere). These cards should be completed last since the parameters depend on the rest of the network.

"B" Input Records - Barge Class Data: The user defines the barge classes in the "B" input data. The input data forms for each barge class include the barge class definitions and the barge class capacities.

"C" Input Redocrd - Commodity Class Specification: Commodity movements are entered in the model by ports of origin and destination and commodity class number. The "C" input data lists each commodity class to be recognized by the model.

"D" Input Records - Dedicated Equipment Data: Individual shipments or sets of shipments may reserve towboats and barges for their transport from origin to destination. These towboats and barges are dedicated to the shipments. They may not be used for other shipments even if they are idle. The dedication is indicated by assigning a dedication index to the shipments concerned and entering the appropriate dedicated equipment input data for that index.

"F" Input Records - Empirical Frequency Distribution: The "F" form defines the probability distribution of a random variable. Distributions defined by "F" data cards may be referenced wherever a random variable is required on other data cards.

"G" Input Records - Commodity Group Specification: commodity classes, as defined by the "C" input data, are aggregated into commodity groups for the purpose of specifying loading and unloading rates for a set of commodity classes with common physical properties and handling characteristics, and for collecting statistics. The "G" input data lists the commodity groups and the associated loading and unloading rates.

"H" Input Records - Lock Chamber Data: Lock chamber data are inserted into the network input data immediately following the lock data. Chambers must be ordered by decreasing size (area).

"L" Input Records - Lock Data: Lock data is inserted into the network input data in the order of appearance of locks within each sector. Lock definition input data is required for each lock in the network. If open pass operations are to be simulated at the lock one, or more open pass schedule cards must follow the lock definition card.

"N" Input Records - Major River System Specifications. One or more waterway network sectors may be aggregated to a major river system. These are defined for output report generation only. The output relative to locks, ports and reaches can be requested by river system, limiting the printing of output reports to only areas of interest as opposed to getting output for the entire system. In the network data, the major river system is specified by placement of "N" card before the first sector or "S" card in the river system.

"P" Input Records - Port Data. The waterway network must include a port at the end points of each sector (junction ports) and at each point where cargo may be loaded into or unloaded from barges.

"R" Input Records - Network Reach Data. The waterway network must include a reach between any two nodes (locks or ports).

"S" Input Records - Network Sector Data. The waterway network may consist of several sectors. All waterway junctions must be at a sector end points and a new sector must be defined when one of the following sector attributes changes; maximum tow size, average tow speed upstream, average tow speed downstream. The sector or "S" card must precede all other network data associated with the sector.

"T" Input Records - Towboat Class Data. The user defines the towboat classes in the "T" input data. Each class requires at least two lines of input, one for the definition and one or more for the areas of operation.

"W" Input Records - route Specification Data. As part of its initial processing, the model calculates a routing table for the network. Consider a tow located within sector i which must travel to a destination in sector j. The (i,j)th entry of the routing table will indicate: (1) which direction the tow should travel (on sector i); and (2) which sector to enter next when it reaches the end of sector i. When the new sector is entered, the table is consulted again for directions from i to j. In this manner, the complete route between any two sectors may be obtained.

If there are portions of the network where more than one route exists between two sectors, the shortest route, based on the estimated tow speeds and lockage times of the S and L records, will be stored. The W record permits the user to override the calculated route in such a case. If used, W records must follow all network data.

Shipment Data File

The WAM requires as input a set of shipments to be moved on the waterways by the fleet of barges and towboats. The data are treated as external events by the SIMSCRIPT simulation. In other words, the WAM is driven by a series of "SHIP" external events input by the user in the form of a shipment list. Each shipment is a demand on the system. This list may be developed from historical movement data such as WCSC data, or from a shipment generator program which requires an actual or projected commodity origin-destination matrix to be input. The set of shipments must be ranked in chronological order.

It is probable that most systems analyses using the WAM will be based on a simulated period of approximately 1 month. Program SHIPGEN was designed to generate shipments for 28 days. As discussed previously, however, an extensive warm-up period may be necessary before the month of statistics-keeping begins. Since the sole purpose of this period is to achieve a steady state, there is no reason why a repetition of the 28-day shipment list will not suffice. Program EXTEND may be used to extend a shipment file to any desired time length by repeating the shipments as necessary. The major data elements of a shipment list are as follows:

- Event Time (day): This is the time in days, at which the shipment arrives at the port ready for loading into barges. The simulation starts at time 0.0. An entry of 3.5 would make the shipment available for lading at noon on the fourth day. the shipments must be listed in chronological order starting from event time 0.0

- Commodity Class Code: The commodity class code is a one or two digit numeric code to identify the commodity class of shipment.

- Shipment Size

- Origin Sector Number

- Origin Port Number

- Destination Sector Number

- Destination Port Number: Ports are numbered separately in each sector. Therefore, two data elements are required to identify a port within the network.

- Trace Flag: Any nonblank character will, under certain run control conditions, generate an output report which traces the events concerning this shipment as they occur during the simulation.

- Dedication Index: If the shipment is to be transported by equipment (towboats and barges) specifically reserved for it, the dedication index is entered. This index refers to the appropriate dedicated equipment input on the "D" type record in the system description file. This record gives the number and types of barges and towboats reserved for the shipment. The same index may be used for several shipments. The movement of these shipments can only be accomplished by the barges and towboats reserved for them. Control of these dedicated movements is established through the dedication index number. This index is the means by which equipment reserved for a particular shipment is identified and matched with the shipment. The "D" input card describes how many and what classes of equipment are dedicated to the particular shipment. Within the model, whenever a dedicated shipment arrives at a port, a search for barges and towboats with the same index number begins. Loading and movement of that shipment cannot be accomplished until equipment with matching dedication indices is available.

  Dedications can control or influence the percentage of commodities shipped, the average tow size, and the empty to full barge ration.

These items in turn have great influence on other activities. Consequently, dedications can be used to control model operation and output.

Because of their direct influence on model activities and output, dedications can be an important control when calibrating the model. They can also be used to simulate the operations of a particular shipper, to predict the impact new equipment design and capacities will have on the system, and to study other areas where the equipment characteristics significantly affect the activity being analyzed. During a WAM calibration effort, dedications may be added when previous runs reveal certain problems. If some ports are not shipping a high percentage of the commodities arriving at them, then several of the large shipments originating from them should be dedicated. If one or more locks shows too few empty barges passing through them, then shipments can be dedicated to create a one-way-loaded-one-way-empty effect. The average tow size should be realistic because it directly effects lock operations. Dedications can be set up to raise the average tow size, if this is a problem.

When setting up dedicated shipments, it is often convenient to assign the same dedication index to groups of shipments with common or neighboring origins and destinations and like commodities. The assigned equipment should be sufficient so as to not be a constraint, but not so excessive as to cause too much light boat activity and too few empty returning barges.

A model user must make several decisions and judgments based upon the particular use for the dedication. These decisions are made because of the many uses of dedications, and because once a dedication is implemented the reaction of the system must be thoroughly analyzed to correlate the magnitude of the reaction of the entire system to the dedication before making any additional changes.

Run Control Data File

Run control input consists of one or two run setup cards followed by a set of "CTRL" event cards which control statistics collection, output production, and termination of the simulation.

- Run Setup Data 1: The use of the first run setup input record is mandatory. It includes the following data elements:

  - "RUN" Card Designation

  - Run Identifier: This is a 4-character, alphanumeric identifier which will be printed in the upper left corner on each page of output. It is selected by the user.

  - Title: The title is a 60-character title which is centered and printed at the top of each page of output. If it is desired to include more descriptive information about the run than will fit in the title, it is suggested that comment cards be inserted at the start of the system description data, where they will be listed with the echoed input data.

- Run Setup Data 2: The use of the second run setup record is optional. Its omission implies acceptance, by the user, of default values. The following data elements are included:

  - Playback Raport Suppression Switches: The program normally echoes all input data records and produces formatted playback reports, beginning the simulation. Since this can be quite lengthy and repetitious from run to run, these playback reports can be selectively suppressed by marking the appropriate columns. Any nonblank character will suppress the playback report. Table 5 indicates which reports may be suppressed. If data echo is suppressed (switch 1), comment cards will still be listed. this provides a means of documenting the data used for a run without listing each record. Cards on which errors are detected will also be echoed regardless of the switch setting.

  - Simulation Suppression Switch: It is occasionally useful to allow a check of the input data without actually making a simulation run. A nonblank entry for this parameter will suppress simulation operations. The program will read and check all input data, including run control and shipment data. (If checking of the shipments is not necessary, simply substitute an empty shipment file.) To insure checking of all data, both maximum error parameters (described below) should be set to 99.

  - Maximum System Errors: This is the maximum number of errors in the system description data which will be tolerated before cancelling the simulation. The default value is zero which will prevent the simulation from beginning if any errors are detected. A higher value should be specified only with extreme caution. The program does not normally attempt to correct errors, so if a run is allowed to continue in their presence, the results are unpredictable. When an input error is detected, the program issues a warning but continues reading and checking the remainder of the data. It is only after the entire system file has been read and checked that the error counter is tested and the run halted if necessary. If 99 is entered an unlimited number of system errors will be permitted.

  - Maximum Simulation Errors: This is the maximum number of errors which are permitted to occur during the simulation portion of a run before the run is aborted. This is independent of the system errors discussed above. However, as with the system errors, caution should be exercised when raising this value above zero. If 99 is entered an unlimited number of simulation errors will be permitted. Most simulation phase errors are related to external event card data. It should be noted that erroneous event names, time fields or illegal numerical input data will generally be detected by the SIMSCRIPT system which will abort the run regardless of the error limit specified here.

- Random Number Seed - Stream 1 (setup) Stream 2 (simulation: The program uses two independent streams of random numbers. Stream 1 is used for initialization of the system and Stream 2 for random values needed during the simulation. The random number seeds initialize the respective stream. If the fields are left blank, the standard SIMSCRIPT supplied seeds will be used. Changing the seeds provides the means for replicating runs, that is, making runs which are identical except for the random numbers used in order to estimate the impact of randomness on the system. At the end of a simulation the current values of the seeds are printed. These are suitable starting values for a subsequent run. Before using other values it is suggested that the SIMSCRIPT User's Manual be consulted for any restrictions which may apply.

o "CTRL" Event Cards: Run control functions during the actual simulation are effected by CTRL external cards which follow the setup data. The data are free format in that there are no fixed columns for the fields. Therefore, there is no input form for these input records. The general form of these cards is:

CTRL time action data*

"CTRL" and the trailing "*" are required by the SIMSCRIPT external event mechanism. It should be noted that the fields described so far are read and processed by the SIMSCRIPT external event mechanism. Errors detected here will result in an immediate program abort regardless of the error limit specified in the run setup data.

- END: The END action terminates the simulation run. An END card is always required. Care should be taken to assue that there are no errors which could prevent it from being recognized. Otherwise, the run could continue indefinitely. The data portion of the END card designates the output reports to be printed. Each report is assigned a number, as given in Table 6. The numbers of the desired reports are listed in free format following the END keyword. If no numbers are specified, all reports will be printed. If it is desired to suppress all reports enter a "0" (zero).

OUTPUT DATA PROVIDED

The output from the WAM includes playback reports of the input data: five system performance reports which summarize the model's activity; an optional, time-sequenced, detailed trace of one or more given shipments, ports, locks, reaches or towboat classes; and an optional data file that is used for statistical analysis postprocessing.

Input Data Playback Reports

The first output function of the model is to "play back" the input data in a series of easily-interpreted reports. One is an echo check which merely lists the input records of the system input file in card-image form. Other playback reports show the input data in format convenient for reading and interpretation. They show exactly how the data supplied by the user were interpreted by the program, which is very useful for detecting data errors. They also provide a record of the conditions simulated. The following reports are provided:

- o Echo Check of System Description Data Set
- o Array Dimensions and Miscellaneous Parameters
- o Waterway Network Data:
  - River Points and Reaches
  - Sectors
  - Junctions
- o Port Data
- o Lock Data
- o Lockage Times Data:
  - Approach and Entry Frequency Distributions
  - Chambering and Exit Frequency Distributions
  - Miscellaneous Frequency Distributions and Parameters
  - Open Pass Data
  - Recreational Traffic Data
- o Commodity Class and Commodity Group Data
- o Towboat Data:
  - Towboat Class Data
  - Towboat Sectors of Operation
- o Barge Data:
  - Barge Class Data
  - Barge Class Capacities
- o Dedicated Equipment Data
- o Empirical Frequency Distribution Data
- o Routing Table Data

The results of simulating the system are presented in five major reports which are normally produced at the end of the simulation run. These reports are:

Lock Utilization and Delay: This report summarizes the utilization of lock facilities and the corresponding delays observed during the run. Statistics for this report are based on vessels completing lockage during the period covered by the report. Vessels undergoing lockage or vessels waiting in the queue at the end of the run (or other time of printing of the report) are not counted. The exceptions to this rule are the maximum queue length and utilization statistics. Note especially that the delay statistics do not include vessels waiting at the end of the run. Furthermore, the average queue length, which is derived form the delay, excludes any contribution from these vessels. Under steady state conditions this is balanced by contributions from vessels which were waiting at the start of the statistics collection period. However, both queue length and delay may be underestimated for overload locks where the queue is continually growing.

The specific items presented in the report are the following:

- Chamber Operations: Number of times chamber was filled (upstream) and emptied (downstream). This includes empty chamber turnbacks.

- Tows: Number of tow served. This does not include light boats.

- Barges, Full and Empty: Number using the lock.

- Cargo: Tonnage passing through the lock.

- Light Boats: Number served.

- Recreational Craft: Number served.

- Delay, Average and Maximum: Time form arrival at lock to start of lockage. This includes both tows and light boats but not recreational craft. Note that delays are associated only with the lock as a whole and not with individual chambers at multichamber facilities.

- Queue Length, Average and Maximum: Number of vessels awaiting lockage, excluding recreational craft.

The second part of the lock report ranks the locks according to the utilization of their main chamber. No new information is presented, but it is included as an aid to determining the most congested locks. Only locks with utilization percentages greater than a percentage value input on the "A" card are included in the list. If zero percent is input, all locks will be listed. The information repeated for each lock in the list is:

- Number of Chambers

- Main Chamber Utilization Percent

- Number of Towboats - the sum of the tows and light boats served

- Tonnage of Cargo

- Average Delay Time

<u>Detailed Lockage Statistics for Selected Chambers</u>: For some of the locks in the network, a more detailed accounting of activity than that available in the Lock Utilization and Delay Report may be desired. This report provides such information for those lock chambers for which detailed statistics collection was requested on the corresponding "H" format data record. A separate report is printed for each such chamber.

The first part of the report contains the following statistics on the various types of lockages in each direction of travel:

- o Lockage Type: Lockages are classified into seven categories for the report. Most of the definitions should be clear; however, the following points may be noted:

  - The first six categories include only those lockages in which at least one tow was served. Lockages, in which only light boats and/or recreational vessels were served, are counted in the "Light/Recr" category even though another classification (e.g., "Open Pass") might apply.

The values presented in the Reach Report are as follows:

- o Tows: Number of tows, not including light boats, which travelled the reach
- o Barges, Loaded and Empty
- o Light Boats
- o Cargo: Kilotons of cargo carried on the reach
- o Kiloton-Miles: Kilotons of cargo multiplied by the length of the reach (Note that this value is also totaled by sector.)
- o Tow Speed, Average and Standard Deviation: Speed statistics are tallied for tows using the sector (Light boats are excluded.)

<u>Equipment Utilization</u>: This report is in two parts, covering towboats and barges.

The statistics presented in the towboat section are the following:

- o Kiloton-Miles per Boat per Day: Average value for boats in the class (Ton-mile statistics are taken when a tow enters a reach, with no adjustments for partially travelled reaches at the start of end of the period.)
- o Percent Time Spent on Reaches
- o Percent Time Spent in Lockage: Includes the actual lockage time, plus chamber turnback if required
- o Percent Time Spent Delayed at Lock
- o Percent Time Spent in Port. Time spent in port operations, that is, picking up and dropping off barges, not including waiting time
- o Percent Time Spent Awaiting Barges: Time spent idle in port waiting for barge loading to be completed
- o Average Tow Size: Based on sampling tow size as a tow enters each reach (Light boats are excluded from this statistic.)

- Percent Time Light: Based on the time spent by boats on reaches, in lockage and delayed at locks. (The percentage of this time in which the towboat is moving no barges is output.)

- Lockages: Number of completed lockages

- Tows: Number of tows served in lockages of the given category

- Barges: Number of barges served

- Cargo: Tons of cargo which passed through the lock

- Light boats: Number of light boats served in lockages of the category (For the first six categories, these will be boats which shared the lockage with a tow.)

- Recreational Craft: Number served, similar to light boats

- Entries and Exits: The number of fly, exchange and turnback entries and exits made (It should be noted that light boats and recreational vessels have no entry or exit type associated with them. In addition, a lockage of a tow which immediately follows (precedes) a lockage in which only light or recreational boats are served is counted as a turnback entry (exit) regardless of the directions of travel involved.)

- Time: The average and standard deviation of the processing times of lockages in the category

The second section of the report expands on the delay statistics for the vessels using the chamber:

- Vessel Type: Vessels are categorized as tows, light boats or recreational vessels.

- Number Delayed

- Delay Time: The average, standard deviation and maximum of the delays for vessels in the category (These are first presented based on all vessels, then based on only those which were actually delayed (that is, excluding zero delays). Caution must be exercised in interpreting the standard deviations printed. The delay times for successive lockages tend to be positively correlated which biases estimates of standard deviation. The reported value will tend to underestimate the true value.)

Port Activity: This report summarizes the cargo and tow movements associated with each port. Note that statistics are collected and presented by the commodity groups defined in input data. It should be also noted that the values for tonnage and barges originated, loaded, shipped and received are not directly comparable. For example, the tonnage shipped during the statistics collection period probably includes cargo loaded prior to it. Under steady state conditions, this will tend to be balanced by tonnage loaded during the period but still awaiting shipment at the end of it, but it is unlikely that the balance will be exact. Similar conditions apply to the other values reported.

The specific items included in the report are the following:

- Originated Tonnage: Tons of cargo which arrived at the port to begin shipment
- Loaded, tonnage and Number of Barges: Cargo is counted as loaded when barges are obtained and loading begins.
- Shipped, Tonnage and Number of Barges: Cargo is shipped when it is picked up by a towboat. The values reflect only cargo which originated at the port, not barges transshipped.
- Received, Tonnage and Number of Barges: Cargo delivered to the port as its final destination (Again, barges received for transshipment are excluded.)
- Average Wait for Barges: Average time between shipment arrival and the start of loading, weighted by tonnage, for cargo loaded during the period
- Average Wait for Towboat: Average time between completion of loading and pickup by a towboat, weighted by tonnage, for cargo shipped during the period (Only cargo originating at the port is counted.)
- Empty and Transshipped Barges, *In and Out*: Number of barges which (1) arrived or departed the port empty, or (2) were dropped off or picked up in a transshipment operation (This shows all barge movements not associated with shipments originating or terminating at the port.)
- Tows Served: Number of towboats which stopped at the port to pick up and/or drop off barges

<u>Traffic by Reach</u>: This report summarizes the tow and cargo movements on each reach of the network. Reach statistics are recorded when a tow enters a reach. No adjustments are made for vessels which have partially travelled a reach at either the start or end of the statistics collection period. The ton-mile statistics in particular may be slightly in error as a result.

- Percent Time in Use: A barge is considered to be in use when it is loaded or in the process of being loaded or unloaded, whether moving or waiting for a towboat.
- Percent Time Empty: Time spent <u>moving</u> empty or awaiting a towboat after being assigned to move empty
- Percent Time Idle: Time spent empty and unassigned in port

Due to the manner in which these statistics are obtained, errors may arise for barges which are being loaded or unloaded at the start and end of the statistics collection period. There is no average bias, however, and the errors should be small compared to the totals.

Output Options

Trace Output: The simulation trace provides a detailed, time-sequenced record of activity for the system or selected portions of it. The output itself consists of a series of messages produced as various actions take place in the simulation. Each message is explained in detail in the User's Manual, however, some general comments are in order at this point:

- o The first field in each message is the simulated time in days.
- o Shipment ("SHIP") numbers are assigned sequentially by the program in order of shipment arrival.
- o The towboat ("TOW") number is a sequence number assigned to each towboat. The numbers are assigned first by order of towboat class and then by dedication index within each class, nondedicated boats receiving the lowest numbers. Hence, it is not difficult to determine the type and dedication of a towboat from its sequence number.
- o Ports, locks and reaches are designated in the form "s-i" where s is the sector number and i the identification number within the sector as given by the input data. Note that ports located at network junctions may be designated by several different sector index pairs.
- o Groups of barges are coded as "n/b" where n is the number of barges and b the barge class.
- o A set of associated switches is given for each message. the message will be printed if any of the appropriate switches has been turned on either by a CTRL TRACE card or by a SHIP card.

PMS Output: The PMS output feature enables the WAM to produce output similar to the information collected by the Corps of Engineers Lock Performance Monitoring System. The output file contains a description of each lockage performed and a record of the make up of each tow, updated whenever barges are picked up or dropped off. This file can be saved for subsequent use by user postprocessing programs.

- o PMS Output File: The file consists of two major types of records: tow or "T" records and lockage of "L" records. One or more tow records are produced whenever a towboat leaves a port where it has picked up or dropped off barges. The most recent set of "T" records for a boat thus describes the current makeup of its tow. Each "T" record can describe two barge groups. As many records as needed to include all the barges in the tow are written. Unused barge group fields are blank. If a towboat drops off all its barges and departs a port light, a record with all barge group fields blank will be written. If the boat waits at the port, however, no record is produced until it leaves.

  At the completion of each lockage, an "L" record is output for each tow or recreational vessel involved. Recreational crafts are identified by a tow number of zero. The makeup of a tow undergoing lockage is determined from the last preceding "T" record(s) for the tow. In order to have a description of each tow available, it will be necessary to turn on PMS output prior to the time at which actual results are desired. In fact, a record of each tow can be guaranteed only if PMS output is turned on at the beginning of the run. In this case, an "L" record for a towboat with no preceding "T" records would indicate a light boat.

- Status Output: The Save/Restore feature of the WAM permits the user to record the status of the simulated system at any point in a run, and to later restore the system to this status at the beginning of a subsequent run. By initializing a run to conditions which existed during a previous run which reached steady state, the user can eliminate or reduce the warm-up period which would otherwise be required before beginning statistics collection. The feature is also useful to the analyst who is uncertain as to the length of run that will be required to obtain useful results; an initial short run can be continued at a later time if the end-of-run status is saved. If desired, certain system parameters such as lockage times or policies may be changed before continuing a run in this manner. The program automatically performs a status save as part of the abnormal termination procedure, to aid in debugging.

  A status file does not record the complete system description, but only the variable elements: shipments in progress, location and status of towboats and barges, etc. when the file is used to initialize a subsequent run, therefore, the normal system description must still be provided. It is possible to change the data from that used in the run which created the status file. However, there are several restrictions on the type of changes permitted:

  - The basic structure of the waterway network cannot be changed. That is, the number and relative location of sectors, ports, locks and reaches must stay the same. The number of chambers at a lock may be changed, as may all parameters describing the network elements.

  - The number, type and dedication of towboats and barges may not be changed. The operating area (permitted sectors of operations) for a towboat class should not be reduced. Other payments describing vessel classes may be modified.

  - the number of commodity classes may not be reduced.

When a restore operation is performed, the model checks that the number of various system entities have not been changed. Fatal error "I-8" is reported if a discrepancy is found. This, however, provides only a partial check on the above restrictions, so the user must take the primary responsibility for adhering to them.

Some data changes, while permitted, may result in temporary anomalous situations in the model. For example, if the capacity of a barge is reduced it might be restored to a state in which it is overloaded. Once the barge delivers its cargo, however, new loadings will reflect the reduced capacity properly. similar situations could result from decreased tow size limits, reduced channel depths, etc.

Conditions at locks are not restored to precisely those existing when the run status was saved. Lockages which were in progress at the time of the save operation are restarted from the beginning when the status is restored. Restoring partially completed lockages would require a number of additional restrictions on changes permitted to lock data between runs.

Because of the inexact restoration of lock conditions and the previously discussed anomalies, it is generally desirable to retain at least a short warm-up period after initializing from a status file. If system parameters have been changed significantly, a somewhat longer warm-up may be required.

Run statistics are not saved as part of the status file. Output from a run initialized from a status file reflects only the current run. The effect is as if a RESET operation were performed at the start of the run.

Finally, it should be noted that simulated time is not restored, but starts at zero at the beginning of each run.

- SNAP.R Output: One of the features of SIMSCRIPT on the BCS is the automatic execution of a routine called SNAP.R whenever the operating system detects an error during execution and there is to be an abnormal program termination. A dummy SNAP.R supplied by the system is executed if one does not exist within the program. The primary advantage of SNAP.R is that selected variables and data structures from the program can be printed out so that maximum information can be gained from the run to help in uncovering the source of the problem.

  The SNAP.R routine in the WAM is the mechanism used for the automatic creation of a status file under error conditions. It also causes the printing of a "link table" with the main output. This table relates each link (port, lock or reach) to its corresponding link number which is assigned by the model during the initialization phase of execution. Since the link numbers appear on the status file, it is necessary to have a link table available in order to interpret the status file. If a link table is not available, it may be necessary to obtain one by making an intention error in a model run. A link table is good as long as the system configuration remains unchanged.

HARDWARE AND SOFTWARE REQUIREMENTS

The WAM has the following hardware and software requirements:

- Terminal (Input/Output) with modem and on-line access to the BCS Timesharing System

- References and user manuals

- SIMSCRIPT II.5 Compiler: The SIMSCRIPT II.5 program for the Resource Requirements Model is currently operational on the BCS system, but can be transferred, with minor changes, to any computer having a SIMSCRIPT

II.5 compiler. The program was originally developed on the CDC CYBERNET system, and can still be used on this system with minor changes.

STRENGTHS

The WAM has the following strengths:

- Optimal tow configurations are determined at the "transportation class" level, whereas, in previous versions of this model (the Flotilla Model), transportation classes were aggregated to create each flow. The costs and characteristics of each transportation class flow are then used to create individual shipment reports that display statistics for a single commodity flow.
- Large selection of detailed data and types of reports provides a user with great flexibility in choice of analytical focus.
- Accounting framework for handling data and model outputs provides results that are internally consistent.
- Broad scope considers virtually all of the more important variables.
- There is extensive documentation on the calibration of the model(s).
- Gives planners and operations personnel a virtually complete picture of a waterway network.
- Provides for detailed comprehensive analysis of waterway transportation resource requirements.
- Data input is accomplished relatively easily.
- Provides for efficient handling of data management routines.
- Provides for examination of the network loops of the feedback relationships of the integral components of the numerous physical systems.
- Frees planners to devote more time to general policy considerations.
- Great flexibility of input and output requirements and of computation techniques enable the program(s) to solve relatively simple problems with minimum effort or elaborate and complex problems with a high degree of accuracy/validity.
- Provides systematic and easy procedure(s) to determine policy impacts.
- Allows incorporation of changes in policy decisions into the model framework.

- Great flexibility of input and output requirements.

- Works with and allows rapid changes in large and elaborate networks.

- Overall efficiency of the simulation process has been implemented by having the model(s) effectively programmed to efficiently handle all of the data (inputs and outputs). This is significant because frequently about one-half of the cost of simulation is incurred in data handling.

- Planning and evaluation procedures are systematic and comprehensive.

- Allows system(s) to accept stochastic inputs and deterministic inputs.

- Sum of regional outputs can be correlated with output from a national model.

- System is on-line and provides graphical interaction between the user and the computer.

- The program(s) has a warning (red flags) system.

WEAKNESSES OR LIMITATIONS OF USE

The WAM has the following weaknesses or limitations of use:

- Environmental costs or opportunity costs for alternative uses of water resources are not considered in the WAM.

- Calculations are expensive if the full-scale model is run and modifications of the basic model are time-consuming and costly. This problem is directly proportional to the data requirements.

- Calibration procedures are tedious.

- Constant parameters (area, depth, velocity, etc.) are assumed to prevail in any one link.

- The minimum amount of data required for this type of model is considerable.

- Solutions are dependent upon the accuracy of the demand data.

- The approach requires substantial inputs of detailed data.

- Effective use of the many options requires much data input which can appear intricate until familiarity is established.

- The full-scale model uses very many data in which errors could occur in individual numbers and not be easily traced. This affects the reliability of the model prediction.

- More basic research is needed to refine the technique and analyze the sensitivity feedback relationships among the important variables.

- The large variety of input options is an asset to an experienced user but a hindrance to a beginner.

- The model can be applied only under steady state conditions.

- The model is not adaptable to small-scale computers.

- The program is very large and can be very expensive if it is run with all options.

- Input data requirement is an enormous quantity that could limit the usefulness of the model.

- Substantial analysis is required to compile inputs.

- The storage requirement is very large.

CHAPTER III
SELECTED DATA SOURCES

INTRODUCTION

This chapter contains abbreviated descriptions of the computerized on-line data bases and published data files that are currently maintained and/or sponsored by the U.S. Army Corps of Engineers, for use by Corps personnel in the conduct of navigation analyses of the Nation's inland waterways and deep draft ports. The pertinent user manuals, containing greater detail than that in the following abbreviated descriptions, are listed in the reference section at the end of this report.

DATA BASE TITLE: PERFORMANCE MONITORING SYSTEM
(also known as: LOCK PERFORMANCE MONITORING SYSTEM)

CODE NAME: PMS Data

COMPILER: Data are gathered by various U.S. Army Corps of Engineers Districts and Divisions throughout the Nation and centrally compiled by:

Engineer Automation Support Activity
U.S. Army Corps of Engineers
P.O. Box 37520
Washington, DC 20013

LOCATION AND AVAILABILITY: Data are stored sequentially on disk and tape files which are accessible in PMS standard report formats from the CYBER 175 Computer at the Boeing Computer Services Company in Bellevue, Washington. Corps personnel desiring to access the data base are advised to contact the:

Navigation Analysis Center
Institute for Water Resources
U.S. Army Corps of Engineers
Casey Building
Fort Belvoir, Viriginia 22060
ATTN: Mr. Francis M. Sharp

Telephone Number: (703) 325-0574

DEVELOPMENT STATUS: Completed

DOCUMENTATION STATUS: Completed

DATA BASE DESCRIPTION

In January 1975, after some 5 years of intensive development, the Office of the Chief of Engineers introduced a new standardized system of lockage data collection and analysis: the Performance Monitoring System (PMS).

The PMS was developed to enable the U.S. Army Corps of Engineers to more effectively carry out its responsibility to operate and maintain in the Nation's inland waterways system, which provides services to the navigation industry. The PMS allows Corps planners and operations personnel to monitor and evaluate the use and operation of navigation locks, to calculate tow operating characteristics, to monitor variations in traffic flows, to compare operating characteristics of one lock with those of other locks, to provide a basis for establishing performance standards, to facilitate implementation of improvements, and to develop the information which the towing industry requires to schedule its activities most effectively.

At about 250 locks along the Nation's inland waterways system, PMS data are collected on standard data collection forms (shift log, lockage logs and vessel logs) by lock personnel. The Corps of Engineers converts the completed forms to machine-readable inputs that are edited and stored in the PMS central library.

Based on the data in the PMS central library, the PMS reporting system can be used to tabulate lock and waterway activity. The PMS reporting system is comprised of 25 programs that are capable of producing 45 reports. The reports can be produced on a monthly, yearly or on-request basis.

INPUT DATA REQUIRED

Data Collection Forms and Procedures: The PMS utilizes three data forms on a routine basis.

The first form, completed at the beginning of every shift by the lockmaster, provides information about the navigation conditions at the lock, such as weather, wind current and surface conditions.

The second PMS form is a detailed account of each lockage. The type of lockage which was performed and the exact times at which each of six lockage events occur are recorded. From these data, the analyst can determine when a lock was in use servicing a tow, the number of tows delayed at any given time, tow delay and lockage times, the relative efficiency of various types of lockages, and so forth.

The third PMS form identifies the towboat, its dimensions, and the number and type of barges being pushed. The amount and kind of cargo carried are also recorded, thereby providing a match with the towboat, commodity, tow configuration and lockage times.

OUTPUT DATA PROVIDED

Output data are provided in the following categories:

- Data Input and Editing
  - Lockage Input Data Report
- Lock Analysis
  - Waterway Traffic Log
  - Lock Analysis Report
    - Average Time in Minutes
    - Frequency Analysis
    - Percentage Analysis
    - Vessel Traffic Analysis
    - Time Distribution
  - Stall Analysis Report
  - Vessel Frequency Analysis Report
  - Lock Utilization Analysis Report
  - Lock Analysis Summary Report
- Exceptional Performance
  - Exceptional Performance Events Report
  - Exceptional Performance Standards Report
  - Exceptional Performance Summary Report
- Detailed Commodity
  - Commodity Summary Report
  - Commodity-Barge Type Report
- Detailed Lock Analysis
  - Arrival Frequency Analysis Report
  - Inter-arrival Distribution Report
  - Delay Time Frequency Analysis Report
  - Horsepower Frequency Distribution Report
- Tow Transit Analysis
  - Tow Transit Analysis: Detailed Vessel Report
  - Tow Transit Analysis: Lock Report
  - Tow Transit Analysis: Summary Report
- Tow Company
  - Detailed Tow Company Analysis Report
  - Tow Company Summary Report
- Lock Summary Reports
  - Maritime Administration: Lock Tonnage Report
  - Maritime Administration: Lockage Report
  - Lock Utilization Summary Report
  - Lock Performance Summary Report
  - Lock Delay Summary Graph
  - Lock Service Summary Graph
  - Lock Queue Summary Graph
- Summary Graphic Reports
  - Tows Processed
  - Tons Processed
  - % Utilization
  - Barges Processed
  - % Empty Barges Processed
  - Total Delay Time
  - Average Delay Time
  - Barges/Minute of Processing
  - Tons/Minute of Processing
  - Tons/Tow
  - Tons/Lockage
  - Tows/Day
  - Tons/Day
  - Barges/Day
  - Barges/Tow
  - Other Vessels/Tow Lockage
  - Average Processing Time Per

HARDWARE AND SOFTWARE REQUIREMENTS

The PMS ha· the following hardware and software requirements:

- Line printer (131 columns)
- Access to the Boeing Computer Services Timesharing System
- Remote batch operations
- Terminal (Input/Output) with modem
- References and user manuals

STRENGTHS

The PMS has the following strengths:

- Allows incorporation of changes in policy decisions into the model framework.
- Evaluation procedures are systematic and comprehensive.
- Sum of regional outputs can be correlated with output from other INSA models.
- In choosing the definitions for lockage types, timings, commodity codes, etc., the INSA task group extended the value of these definitions by using these same definitions and terms in the INSA simulation models and analytical routines. INSA thereby provides Corps planners with a one-to-one relationship between the simulated universe and the one being monitored and used as a data source.

WEAKNESSES OR LIMITATIONS OF USE

The PMS has the following weaknesses or limitations of use:

- Report outputs are not flexible. New reports must be written if aggregations other than monthly totals by lock are required.
- Retrieval of a subset of data may be expensive because the data are stored sequentially on volumes of magnetic tape that are not necessarily segregated by year. A sequential search of several years' data is sometimes required.
- Data have not been reported by some Corps districts for some months.
- Data library is designed to key on the Corps district; it is difficult and costly to make other aggregations, e.g. by river.
- There is no national summary or report on lock statistics.

DATA BASE TITLE: WATERBORNE COMMERCE STATISTICS
(Contain three waterborne commerce software packages)

CODE NAMES: DOCK-TO-DOCK Data File

PORT/PORT EQUIVALENT Data File
(Also known as PORT/PORT EQUIVALENT-TO-PORT/PORT EQUIVALENT Data File)

REGIONAL WATERWAYS Data File

COMPILER:

Waterborne Commerce Statistics Center
U.S. Army Corps of Engineers
3545 Interstate 10
Crutcher Tufts Building - Second Floor
Metarie, Louisiana

LOCATION AND AVAILABILITY: Data are stored sequentially on magnetic tapes on a Honeywell computer at the Engineer Automation Support Activity (EASA), and on a Burroughs computer at Data Resources, Inc. (DRI). Both EASA and DRI are operating out of offices in Washington, DC. By means of a Navigation Analysis Center (NAC) subscription with DRI, the data tapes are accessible to Corps personnel through a DRI Data Base Management System which services DRI clients. Under the NAC subscription with DRI, Corps personnel with a valid DRI account number may obtain copies of the data tapes through DRI or NAC. Other Corps personnel desiring to obtain copies of the data tapes are advised to contact the:

Navigation Analysis Center
Institute for Water Resources
U.S. Army Corps of Engineers
Casey Building
Fort Belvoir, VA 22060
Attn: Mr. Francis M. Sharp

Telephone Number: (703) 325-0574

DEVELOPMENT STATUS: Completed through the year 1980

DOCUMENTATION STATUS: Completed

DATA BASE DESCRIPTION

The Waterborne Commerce Statistics Center (WCSC), of the United States (U.S.) Army Corps of Engineers (CE), is the implementing element of the CE Waterborne Commerce Statistics Program. In compliance with various ACTS of Congress, extending back to the River and Harbor Act of 22 September 1922, the Congress has assigned to the U.S. Department of the Army the duties of collecting, compiling and publishing statistical information on the Waterborne Commerce of the U.S. On prescribed forms approved by the Office of Management and Budget (OMB) under the Federal Reports Act of 1942, waterborne traffic movements are reported to the Corps of Engineers by all commercial vessel operators of record for the domestic movements of their vessels. While the WCSC data base as currently collected and compiled is designed to meet the administrative requirements of the U.S. Department of Defense (DOD) in the performance of its statutorially-assigned duties, it also provides useful data for other governmental departments, shipping and other commercial concerns, and others interested in transportation.

The WCSC foreign data are confined to movements by water, and are reconcilable with published reports of the U.S. Bureau of the Census (hereinafter known as the Census Bureau). The foreign commerce data are furnished to the Corps of engineers by the Census Bureau under a working arrangement sponsored by the OMB. The individual domestic reports from commercial vessel operators generally pertain to an individual vessel movement completed in one direction and to the origin and destination of each individual commodity involved in the vessel movement. Under the sponsorship of the OMB Office of Statistical Policy, and in cooperation with all federal agencies engaged in collecting and compiling data on shipping, a uniform system of freight classification was developed to classify the foreign and domestic commerce data that are collected and compiled by the WCSC. This classification system is known as the Commodity Classification for Domestic Waterborne Commerce, and is applied comprehensively, with some exceptions stemming from Census Bureau modifications of foreign trade data in conformance with bureau policies and procedures.

The trips of vessels at ports are reported as inbound and outbound. Inbound trips represent the entrances and arrivals of vessels. Outbound trips represent the clearances or departures of vessels. The number of trips denotes the number of individual vessel movements on a waterway in each direction; a single trip is counted for each vessel using the waterway in a continuous direction regardless of the number of stops made on the waterway. In order to expedite data processing and to reduce costs, sample counts instead of complete counts are taken of some towboat trips and empty barge movements. When sample counts are used, the number of towboat trips is calculated from a sample count of 70 percent or more of the total towboat movements reported, and the number of barge trips is derived from a sample count of more than 85 percent of the total barge movements reported. The foreign trade component of the number of trips is furnished by the Census Bureau on the basis of data compiled from customs entrance and clearance forms. Adjustments are made, if necessary, to trip counts to more accurately reflect actual traffic patterns (e.g. inbound vs. outbound trip counts).

Domestic traffic is defined as all commercial vessel movements among continental and noncontiguous U.S. ports, and on the inland rivers, canals, and connecting channels of the U.S., Puerto Rico, and the U.S. Virgin Islands, excluding the Panama Canal. All commercial vessel movements between the U.S. and foreign countries, between Puerto Rico and foreign countries and between the U.S. Virgin Islands and foreign countries are classified as foreign traffic. Traffic with the Panama Canal is classified as foreign. Shipments of domestic merchandise and re-exports of foreign merchandise are defined as exports. Imports include inbound merchandise for direct consumption and entries into custom bonded storage and manufacturing warehouses. Intransit merchandise is defined by the Census Bureau as merchandise coming into the U.S. from a foreign country and shipped to a foreign country without having been entered as an import, and is considered an import when unloaded from a vessel and an export when loaded on a vessel. Statistics on military cargo in DOD vessels and on trade between foreign countries and U.S. territories and possessions (Guam, Wake, American Samoa, etc.), are excluded from the WCSC data.

Export shipments and various items (listed by the Census Bureau) that affect national security, are not published in terms of the individual commodities shipped (e.g. export shipments under various foreign aid programs on DOD operated vessels, which could be either American flag vessels under some type of charter or vessels owned by the DOD). Cargo moved for military agencies in commercial vessels is reported as ordinary commercial cargo. In compiling the WCSC data, each entire movement is included in the year when the movement was completed although the shipment may have originated in the preceding year, except that beginning with calendar year 1961, a cutoff date of 28 February was instituted for the processing of reports from commercial vessel operators covering the prior year's completed movements.

INPUT DATA REQUIRED

The primary input data that are required to use the data base are the following input search parameters:

- o Location codes, which may be defined by 8-digit port/dock codes or by 5-digit port codes or by 4-digit port/waterway codes.
- o Specifications as to type of search, which may be conducted in terms of locations, vessel types, vessel drafts, vessel operating companies, commodity types, and traffic volumes.

OUTPUT DATA PROVIDED

Tables 4 and 5 show examples of the kinds of WCSC data that are provided.

TABLE 4

WATRBORNE COMMERCE STATISTICS CENTER DATA

TYPES AND RECORD LAYOUTS OF DATA MAINTAINED ON MAGNETIC TAPES BY THE EASA*/

	FIELD NAME	1969-77 FIELD NO.	1978-79 FIELD NO.
1.	District	1-2	1-2
2.	Vessel Name	3-7	3-7
3.	Vessel Type	8	8
4.	Number of Trips	NONE	9-14
5.	Shipping Month	9	15
6.	Shipping Day	10-11	16-17
7.	Shipping Port	12-16	18-22
8.	Shipping Dock	17-19	23-24
9.	Receiving Year	20	26
10.	Receiving Month	21	27
11.	Receiving Day	22-23	28-29
12.	Receiving Port	24-28	30-34
13.	Receiving Dock	29-31	35-37
14.	Type of Service	32	38
15.	Type of Traffic	33-34	39-40
16.	Commodity Code	35-38	41-44
17.	Short Tons	39-46	45-52
18.	Alternate 2	47-48	53-54
19.	Vessel Operator	49-53	55-59
20.	Alternate	54-55	60-61
21.	Receiving ID No.	56-62	62-68
22.	Shipping Year	63-64	NONE
23.	Shipping BEA	65-67	69-71
24.	Shipping PE	68-71	72-75
25.	Shipping PE Name	72-87	76-91
26.	Receiving BEA	88-90	92-94
27.	Receiving PE	91-94	95-98
28.	Receiving PE Name	95-110	99-114
29.	FILLER	111-120	115-120

TYPES OF DATA MAINTAINED ON-LINE BY THE DRI*/

- Commodity Identification-Description
- Origin-Destination Identification
- Weight of Shipment
- Number of Trips
- Shipping-Receiving Time Data
- Service-Traffic Description
- Vessel Name-Type
- Vessel Operator Identification

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*/ EASA is a contraction of "Engineering Automation Support Activity", and DRI is a contraction of Data Resources, Inc.

TABLE 5

WCSC DATA BASE FILES MAINTAINED ON-LINE BY THE DRI

	FILES NAMES	CODE NAME	NUMBER OF NUMBERS	ESTIMATED STORAGE REQUIREMENTS RECORD SIZE (BYTES)	STORAGE (1,000 BYTES)
1.	WCSP Detail	(WCSP)	2,500,000	160	400,000
2.	Regional ID Master	(RGID)	30	100	3
3.	Port Master	(PORT)	12,000	100	1,200
4.	Dock Master	(DOCK)	60,000	100	6,000
5.	Commodity Master	(COMM)	500	110	55
6.	Routing Master	(ROUT)	80,000	60	4,800
7.	District-Operator-Vessel Master	(DOVM)	60,000	100	6,000
8.	Special Category Master	(SPCL)	100	30	3
9.	Waterway Master	(WTWY)	5,000	60	300
10.	Region ID-Seq Master	(RGSQ)	150,000	40	6,000
11.	Vessel Name Master	(VESS)	60,000	70	4,200
12.	Operator Name Master	(OPER)	2,500	70	175
13.	Port Name Master	(PTNM)	12,000	70	840
14.	Dock Name Master	(DKNM)	60,000	70	4,200
15.	Phonetic Cross Reference	(PKEY)	15,000	30	450
16.	Phonetic Cross Reference	(PHCR)	100,000	60	6,000
17.	Project Master	(PROJ)	4,000	140	560
18.	Port-Dock Cross Reference	(PDCR)	60,000	40	2,400
19.	Routing Detail	(RDTL)	400,000	60	24,000
20.	Commodity Name Master	(CMNM)	1,000	60	60
21.	Census Commodity Master	(CNSC)	1,000	40	40
22.	Census Port Master	(CNSP)	10,000	35	350
23.	Commodity Cross Reference	(CMCR)	1,000	40	40
24.	Port Codes Reference	(PTCR)	10,000	40	400
25.	Region ID-Commodity Cross Reference	(RCCR)	2,000	40	80
	Subtotal W/O WCSP Detail		1,106,130	-	68,156
	TOTAL STORAGE REQUIRED		3,606,130	-	468,156

HARDWARE AND SOFTWARE REQUIREMENTS

The WCSC data base has the following hardware and software requirements:

- o Access to the timesharing system
- o Remote batch operations
- o Line printer (131 columns)
- o Input/output terminal (ASCII) with 300 baud modem
- o Reference and user manuals:
    - WCSC Port and Dock Manual
    - WCSC Port and Dock Descriptions
    - WCSC Vessel Manual
    - WCSC Vessel Operators Manual
    - WCSC Query System Users Manual

STRENGTHS

The WCSC data has the following strengths:

- o The broad scope of the WCSC data banks and up-to-date nature of the data are appropriately combined so as to provide Corps of Engineers users a large menu of data that meet most of their requirements.
- o In 1984, by the use of search parameters listed in libraries, subscribers may search the WCSC data banks to retrieve information which satisfies their specific requirements.

WEAKNESSES OR LIMITATIONS OF USE

The WCSC data base has the following weaknesses or limitations of use:

- o Confidentiality constraints require that access be limited to Corps of Engineers personnel.
- o Only simple queries are currently possible. However, a new and more sophisticated query capability is being developed and will become available in 1984.
- o Depending on the complexity of the query and the calendar year of the data requested, overnight turnaround may be required even under the new query capability.

DATA BASE TITLE: SHIP CHARACTERISTICS LIBRARY (also known as: SHIPS LIBRARY)

CODE NAME: MARDATA (SL)

COMPILER: Data are compiled throughout the world by the offices of Lloyd's Register of Shipping, Limited, which has offices in the United States at:

Maritime Data Network, Ltd.
300 Broad Street
Stamford, Connecticut 06901

LOCATION AND AVAILABILITY: By means of a Navigation Analysis Center contract with Maritime Data Network, Ltd., the data base is accessible on-line to Corps field personnel through a data base management system installed on a General Electric Mark III computer system which services clients of Maritime Data Network, Ltd. Corps personnel desiring to obtain output (especially large-scale output) from the data base, or to independently access the data base, are advised to contact the:

Navigation Analysis Center
Institute for Water Resources
U.S. Army Corps of Engineers
Casey Building
Fort Belvoir, Viriginia 22060
ATTN: Mr. Francis M. Sharp

Telephone Number: (703) 325-0574

DEVELOPMENT STATUS: Completed

DOCUMENTATION STATUS: Completed

DATA BASE DESCRIPTION

This Ship Characteristics Library is an on-line interactive data base containing information on the characteristics of practically all commercial ships of the world over 1,000 gross registered tons. The data base has entries on nearly 30,000 commercial ships. A large-scale General Electric (GE) Mark III computer stores the data files which cover 66 ship characteristics that are reported in 5 categories: Identification, Registration and Classification, Hull Description, Cargo Facilities and Machinery. Data for the files are furnished by Lloyd's Register of Shipping. The data base is compiled and updated monthly by the 250 Lloyd's Register offices in 90 countries. Instant access to the data base is available through GE's Timesharing Network which uses worldwide satellite communications, or through commercial telex.

INPUT DATA REQUIRED

Subscribers may search the Ship Characteristics Library to retrieve names of vessels which satisfy particular requirements or combinations of requirements. There is an input or search parameter for each parameter listed in the library. The search parameters are listed and defined in the User's Manual. (See section on References at end of this report.)

OUTPUT DATA PROVIDED

Output data are provided in the following categories:

1. Bale Cubic
2. Breadth
3. Builder
4. Bulbous Bow
5. Bunker/Capacity
6. Bore, Cylinder
7. Call Sign
8. Cargo Type
9. Casualty Data Availability
10. Classification Society
11. Containers, No. of 20' Equiv.
12. Containers, No. of 40'
13. Containers, No. of 20' Equiv.
14. Cranes, Largest
15. Cranes, No. of
16. Deadweight
17. Delivery Date
18. Depth
19. Derricks, No. of
20. Derricks, Largest
21. Design Type (Ship)
22. Diesel Engines, No. of
23. Diesel Cyl., No. of
24. Draft
25. Engine Builder
26. Engine Designer
27. Flag
28. Fuel Consumption
29. Function
30. Gear, Safe Work Load
31. Grain, Cubic
32. Gross Tons
33. Hatch, Max, Wdth.
34. Hatch, Max. Wdth.
35. Hatches, No. of
36. Holds, No. of
37. Holds, Max. Lgth. of
38. Horsepower
39. Hull Number
40. Ice Classification
41. Inert Gas System
42. Insulated Capacity
43. Lgth. Btwn. Perpend.
44. Length Overall
45. Lighters, No. of
46. Liquid Cubic

47. Machinery Loc.
48. Name
49. Net Tons
50. Nvgtl. Aids
51. No., Lloyd's
52. No., Official
53. Owner
54. Psgrs., No. of
55. Port of Regist.
56. Prop., Cntr. Ptch. of
57. Propulsion Type
58. Screws, No. of
59. Self-Unload
60. Ship, Record Del.
61. Ship Type
62. Speed (knots)
63. Stroke, Piston
64. Survey Date
65. Tanks, No. of
66. Update, Last

HARDWARE AND SOFTWARE REQUIREMENTS

The Ship Characateristics Libary has the following hardware and software requirements.

- On-line access to GE Mark III Computer System
- References and user manuals
- Terminal (Input/Output) modem

STRENGTHS

The Ship Characteristics Library has the following strengths:

- The data base is continuously on-line and is updated monthly.
- The flexible user-oriented search program allows a user to select parameters and indicate the value or range of values that are of interest to him.
- A user can print search results in a report that he specifies.
- Costs can be substantially reduced by suspending the processing. A user will get a 40 percent cost saving by using the "DEFER" search command that suspends his search for up to 3 hours, and a 60 percent cost saving by using the "ONITE" search command that suspends his search overnight. In either case, the actual searching will take place without the terminal being connected.
- On-line user assistance is provided to give information search instructions, changes to User's Manual, parameter abbreviations, and detailed explanations and valid settings for specific parameters.
- Search results can be sorted chronologically, alphabetically or sequentially dependent upon the key parameter(s) chosen.
- The statistical search feature provides an efficient means to display search results in multidimensional matrices that may be subdivided into several categories respectively.

WEAKNESSES OR LIMITATIONS OF USE

The Ship Characteristics Library has the following weaknesses or limitations of use:

- o Search results cannot be stored directly on non-MARDATA devices. Only hard-copy output is available from MARDATA. A feature should be provided that would enable a user while still on-line to cross-tabulate and produce hard-copy output from a merged data file composed of search results from different data bases. MARDATA advises that such a feature may be available to subscribers in 1 or 2 years.

- o Search results from different data bases cannot be merged or cross-tabulated while still on-line.

- o Search results cannot be routed to and printed on a high speed printer.

DATA BASE TITLE: CHARTER FIXTURE LIBRARY (also known as: CHARTER FIXTURES)

CODE NAME: MARDATA (CF)

COMPILER: Data are compiled throughout the world by the offices of Lloyd's Register of Shipping, Limited, which has offices in the United States at:

Maritime Data Network, Ltd.
300 Broad Street
Stamford, Connecticut 06901

LOCATION AND AVAILABILITY: By means of a Navigation Analysis Center contract with Maritime Data Network, Ltd., the data base is accessible on-line to Corps field personnel through a data base management system installed on a General Electric Mark III computer system which services clients of Maritime Data Network, Ltd. Corps personnel desiring to obtain output (especially large-scale output) from the data base, or to independently access the data base, are advised to contact the:

Navigation Analysis Center
Institute for Water Resources
U.S. Army Corps of Engineers
Casey Building
Fort Belvoir, Viriginia 22060
ATTN: Mr. Francis M. Sharp

Telephone Number: (703) 325-0574

DEVELOPMENT STATUS: Completed

DOCUMENTATION STATUS: Completed

DATA BASE DESCRIPTION

The Charter Fixture Library is an on-line interactive data base containing over 28,000 current and historical fixture records of charter market information as reported in various marine news sources, broker's reports and other industry sources worldwide, since the beginning of 1976. The Charter Fixture Library contains entries on many, but not all, of the nearly 30,000 commercial ships that are covered in the Ship Characteristics library which is also compiled by Lloyd's Register of Shipping. A large-scale General Electric Mark III computer stores the data files which contain all reported voyage fixtures and time fixtures for tanker and dry cargo. Among the information contained in a voyage fixture would be ship name, charterer's name, deadweight, cargo, load area, discharge area, rate and lay cancellation days. A time fixture would include ship name, charterer's name, period, rate, delivery and redelivery date and area. All reported charter fixtures are immediately entered into the system on a daily basis directly from the reporting areas in order to make the latest information available to users. Subsequently, the compiled information undergoes verification and revision to correct or include missing data. Approximately 200 to 250 new charter fixtures are added each week. Instant access to the data base is available through GE's Timesharing Network which uses worldwide satellite communications, or through commercial telex.

INPUT DATA REQUIRED

Subscribers may search the Charter Fixture library to retrieve names of vessels which satisfy particular requirements or combinations of requirements. There is an input or search parameter for each parameter listed in the library. The search parameters are listed and defined in the User's Manual.

OUTPUT DATA PROVIDED

Output data are provided in the following categories:

Dry Time	Dry Voyage	Tanker Time	Tanker Voyage
1. Charterer's Name	1. Cargo Quantity	1. Cargo Type	1. Cargo Quantity
2. Comments	2. Cargo Type	2. Charterer's Name	2. Cargo Type
3. Cubic Capacity	3. Charterer's Name	3. Comments	3. Charterers' Name
4. Date of Update	4. Comments	4. Date of Update	4. Comments
5. Deadweight	5. Consecutive Voyages	5. Deadweight	5. Consecutive Voyages
6. Delivery Area	6. Date of Update	6. Fixture Data	6. Date of Update
7. Fixture Date	7. Discharge Area	7. Fixture Number	7. Discharge Area
8. Fixture Number	8. Fixture Date	8. Fixture Type	8. Fixture Date
9. Fixture Type	9. Fixture Number	9. Fuel Consumption	9. Fixture Number
10. Fuel Consumption	10. Fixture Type	10. Lay/Cancel Day	10. Fixture Type
11. Lay/Cancel Days	11. Lay/Cancel Days	11. Period of Charter	11. Lay/Cancel Days

12. Period of Charter	12. Loading Area	12. Rate	12. Loading Area
13. Rate	13. Rate	13. Redelivery Date	13. Rate
14. Redelivery Area	14. Ship's Name	14. Ship's Name	14. Ship's Name
15. Redelivery Data	15. Source	15. Speed	15. Source Code
16. Ship's Name	16. Terms of Charter	16. Source Code	
17. Speed			
18. Source			

HARDWARE AND SOFTWARE REQUIREMENTS

The Charter Fixture Library has the following hardware and software requirements:

- o On-line access to GE Mark III Computer System
- o References and user manuals
- o Terminal (Input/Output) Modem

STRENGTHS

The Charter Fixture Library has the following strengths:

- o The data base is continuously on-line and is updated daily.
- o The fixture records are organized by fixture type: Dry Voyage, Dry Time, Tanker Voyage, Tanker Time subarranged chronologically by fixture date within each type.
- o A flexible user oriented search program is provided which allows a user to select parameters and indicate what value or range of values that are of interest to him.
- o Upon retrieval of the fixtures that meet all of the parameter specifications, the program then allows a user to print the fixture records in a report he specifies.
- o Costs can be substantially reduced by suspending the processing. A user will get a 40 percent cost saving by using the "DEFER" search command that suspends his search for up to 3 hours, and a 60 percent cost saving by using the "ONITE" search command that suspends his search overnight. In either case, the actual searching will take place without the terminal being connected.

- On-line user assistance is provided to give information on search instructions, changes to user's manual, parameter abbreviations, and detailed explanations and valid settings for specific parameters.

- Search results can be sorted chronologically, alphabetically or sequentially dependent upon the key parameter(s) chosen.

- The statistical search feature provides an efficient means to display search results in multidimensional matrices that may be subdivided into several categories respectively.

WEAKNESSES OR LIMITATIONS OF USE

The Charter Fixture Library has the following weaknesses or limitations of use:

- Search results cannot be stored directly on non-MARDATA devices. Only hard-copy output is available from MARDATA.

- Search results from different data bases cannot be merged or cross-tabulated while still on-line.

- Search results cannot be routed to and printed on a high speed printer.

- A feature should be provided that would enable a user while still on-line to cross-tabulate and produce hard-copy output from a merged data file composed of search results from different data bases. MARDATA reports that such a feature may be available to subscribers in 1 or 2 years.

DATA BASE TITLE: DATA RESOURCES, INC.
(Contains several data bases with titles that are described in the data base description below)

CODE NAME(S): Several Code Names
(Code names are listed and described below)

COMPILER:

Data Resources, Inc.
1750 K Street, NW - Ninth Floor
Washington, DC 20006
Attn: Mr. Steve Mueller (Systems Operations), or
Mr. Charles Nason (Procurement of Services)

Telephone Number: (202) 862-3700

LOCATION AND AVAILABILITY: Data are stored sequentially on magnetic tapes on a Burroughs computer at Data Resources, Inc. (DRI) in Washington, DC. Much of the data is also published periodically by DRI. Through a DRI data base management system, Corps personnel with a valid DRI account number may access the data bases on-line and obtain the data in the form of publications and/or tapes. Other Corps personnel desiring to access the data bases on-line and obtain the data in the form of publications and/or tapes are advised to contact the:

Navigation Analysis Center
Institute for Water Resources
U.S. Army Corps of Engineers
Casey Building
Fort Belvoir, VA 22060
Attn: Mr. Francis M. Sharp

Telephone Number: (703) 325-0574

DEVELOPMENT STATUS: Completed

DOCUMENTATION STATUS: Completed

DATA BASE DESCRIPTION

OVERVIEW

The following sections represent an overview of the major DRI data sources and services of interest to the U.S. Army Corps of Engineers (CE). Through contractual arrangements with the U.S. Department of Defense (DOD) and the Office of the Chief of Engineers (OCE), the Corps field operating agencies are able at minimum costs to access on-line DRI data sources, and to acquire various DRI publications pertaining to DRI forecasts and DRI historical collections of economic information.

INPUT DATA REQUIRED

Data provided by DRI are organized and stored in distinct databanks. Because these databanks exist outside the EPS workspace environment, the time series data must be brought into the workspace before analysis can be done. "Data in EPS" refers to the access or creation of time series data in the EPS workspace environment. Although the workspace is initially empty of data, EPS automatically provides a large group of options which modify how EPS carries out a command. The most important options for time series work are SOURCE, AUTOSOURCE, FREQUENCY, and INTERVAL. If a prospective user is unfamiliar with EPS workspace environments, he is advised to contact the Corps of Engineers Navigation Analysis Center for assistance.

OUTPUT DATA PROVIDED

Although there is shown on the next page a lengthy list of DRI subscription services for economic information available to the U.S. Department of Defense as of June 1982, the focus here will be on the following four DRI services deemed of most utility to the conduct of transportation-related studies by the Corps of Engineers:

- TRANSPORTATION SERVICE
- REGIONAL INFORMATION SERVICE
- COST EFFECTIVE SERVICE
- INTERNATIONAL TRADE DATA

DRI SUBSCRIPTION SERVICES FOR ECONOMIC INFORMATION
AVAILABLE TO THE DEPARTMENT OF DEFENSE AS OF JUNE 1982

U.S. Economic Services

U.S. Macroeconomic Forecasting (with Defense Adjustment Workspace)
U.S. Cost Forecasting (with Defense Deflators Model)
Defense Deflators Data Base

BUDGETRACK database (DOD and NASA budget information)
- Occupational Employment Model
- Critical Materials Model
- Regional Information Service
- County Data Base
- Demographic Economic Models (DECO)
- Utilities Cost Forecasting (Handy-Whitman)
- Agriculture Data Base
- DRIFACS Financial & Credit Statistics

Interindustry/Industrial Services

Steel
Transportation
Interindustry (with Defense Economic Impact Modeling System)
Energy
F.W. Dodge construction Statistics

International Services

Macroeconomic & Cost Forecasting Models of:

- Japan
- Europe

Canadian Macroeconomic Model
Latin American Model
East Asian Model
Middle East and African Data
International Trade Information Service
World Bulletin

IMF Data Bases:

- International Financial Statistics
- Directions of Trade
- Balance of Payments

OECD Data Bases:

- Main Economic Indicators
- National Income Accounts
- Trade Series A
- World Bulletin

DRI TRANSPORTATION SERVICE

In general, the DRI Transportation Service provides a comprehensive analytical system, consulting support, and special project capability to aid professionals in evaluating the factors that may influence the transportation environment in the 1980s. The DRI Transportation Service also provides current and projected multimodal transportation costs on a vessel-specific and port level basis. These data have been used in Corps studies in areas such as deep draft ports, channelization, and coal exports. Changes in the U.S. economy, in individual industries, in competing transportation modes, and in government regulation can be analyzed in terms of their impacts on modal traffic patterns, rates and costs, and equipment demands.

Quarterly and annual model traffic forecast freight movement by over 100 commodity groups for five transportation modes: rail, total truck, regulated truck, water and pipeline. Concepts forecast include tonnage, carloads, ton-miles, and revenue. The models can be used to:

- evaluate shifts in market share from one mode to another and among individual carriers;
- examine the effect of changes in demand for various transportation modes;
- prepare alternative scenarios reflecting different levels of industry output or regulatory changes; and
- monitor traffic for purposes of scheduling, capacity and facility planning and overall operations efficiency.

The rate and cost models provide forecasts of cost components (labor, fuel, materials and supplies, and equipment, among others) as well as rates for three transportation modes: rail, motor carrier, and barge. These models allow analysts to evaluate the relative cost behavior and financial condition of different carriers over time. Clients typically use these models to:

- examine the effects of escalating costs on modal rates;
- investigate alternative pricing strategies and their impacts on traffic patterns; and
- prepare and justify rate submissions.

MAJOR DRI DATA BASES

- Central Transportation Data Base: over 25,000 time series related to modal commodity traffic, financial and operating statistics, modal equipment data, modal cost and rate information.

- Commodity Flow Data Bases: railroad and waterborne traffic movements among U.S. regions.
- UMLER Railcar Data Base: ownerships information for all car types including age and capacity data.
- American Railway Car Institute: rail equipment data on orders, deliveries, and backlog by car type.
- Census of Transportation: Commodity Traffic Survey and Truck Inventory and Use Survey.

OTHER DATA SOURCES FOR MAJOR DRI DATA BASES

- <u>UMLER - Universal Machine Language Equipment Register - 1981</u>

  Equipment counts by cubic foot capacity range and age interval, by 4 character AAR car codes

- <u>Interstate Commerce Commission (ICC) 1% Waybill Access - 1980</u>

  Possible Traffic Classes:
  Tons, Carloads, Revenue, Ton-miles

  Car Codes:
  4 Character American Association of Railroads (AAR)
  AAR mechanical design

  Commodity Codes:
  Two-, Three-, Four-, Five-Digit STCC codes
  AAR commodity codes

- <u>State-to-State Waybill</u>

  SPLC to SPLC access of the Waybill for the same concepts and commodities.

- <u>TOFC/COFC - 1% Waybill</u>

  Allows access to TOFC/COFC data in the Waybill by commodities, for tons, carloads, revenue.

- <u>Freight Commodity Statistics - Annual</u>

  Four Dimensions
  Class I Railroads (84 available)
  STCC Codes (500 available)
  Years (1972-1980)
  Traffic Concept (carloads, tons, for originated & terminated, originated & delivered, received & delivered, and gross freight revenue)

- AAR Truck & Waterway Information Center (TWIC)

  Survey data
  National Motor Transport Data Base
  Truck Shipments by 3-digit TWIC codes, for origin state to destination state
  Annual, 1978 to 1980

- Waterborne Commerce Statistics Center (WCSC)
  National Waterways Data

  Quarterly, 1979:1 to 1979:4
  158 4-digit Commodities
  66 Waterway regions
  Origin-destination information available for ten different traffic classes

- Truck Fleet-owner Database

  Regulated and private car and truck fleets
  Company name, location by address and zip code, vocation, fleet size, and fleet characteristics (type of cargo)

SELECTED DRI HISTORICAL TRANSPORTATION DATA BANKS

- Modal Traffic
- Rail Industry
- Truck Industry
- Key Indicators

MODAL TRAFFIC

General Concepts

- Commodity movements by major freight modes: rail, regulated truck, waterborne, and pipeline.

Sources and Data

- Air Transport Association of America - monthly figures on rev. ton-miles, passenger miles, seat miles, and passenger load factors.

- American Trucking Assn., Inc. - monthly truck tonnage indexes, change in tonnage at truck terminals, and quarterly carrier information.

- Association of American Railroads - weekly and quarterly CS54A and CS541 revenue freight loaded by 21 commodities and for Class I rr, ICC regions, and U.S. total. Also weekly carloads by cartype.

- Interstate Commerce Commission - Freight Commodities Statistics Rail and truck tons originated or terminated, annually, by 5-Digit STCC and ICC region.

The data files listed below are located in Data Banks that have the following code names: @TR/FA,@TR/FQ,@TR/FM,@TR/FW

Series Prefixes

o Air Traffic Series	
Available seat-miles flown	ATASM
Passengers east bound	PEB
Passenger load factors	ATPPLF
Passengers west bound	PWB
Revenue passenger-miles flown	ATRPM
Revenue ton-miles, freight	ATRTMF
Revenue ton-miles, mail	ATRTMM
o Pipeline Series	PT
o Rail Traffic Series	
Carloads	RTCL
Carloads originated	RTCLO
Carloads terminated	RTCLT
Freight revenue	RFGFR
Tons originated	RTTO
Tons terminated	RTTT
Trailers loaded	RTTL
o Truck/Motor Carrier Traffic Series	
Motor carrier ton-miles	TTPTM
Motor carrier tonnage	TTPT
Revenue tons hauled	TTT
Tonnage index	TTJ
Truckloads originated	TTTLO
Truck tonnage at terminals	TTJT
Truck tons originated	TTTO
o Waterborne Traffic Series	
Ton-miles	WTTM
Tonnage	WTT

RAIL INDUSTRY

General Concepts

- o time series related to Class I and II railroad operations, finances, costs, equipment demand and supply, and freight rate indexes.

Sources & Data

o American Railway Car Institute	- monthly data on new and rebuilt freight car deliveries and orders.
o Association of American Railroads	- monthly revenue freight car ownership and status. Quarterly indices of railroad costs, rate increases, industry/income and revenue data.
o Interstate Commerce Commission	- annual operating data such as fuel costs, investment, employment, number of companies, freight revenue by 5-Digit STCC. Quarterly operating statistics by road and income. RR miles owned.
o U.S. Dept. of Labor Bureau of Labor Statistics	- Railroad freight price indexes at monthly, quarterly and annual frequencies.

The data files listed below are located in data banks that have the following code names: @Tr/NM,@Tr/NQ,@TR/NA

Series Prefixes

o Equipment Statistics

Autorack cars	RKFCFA
Backlogs	RKFCBL
Box cars	RKFCB
Cabooses	RKFCC
Deliveries	RKFCDEL
Flat cars	RKFCF
Gondolas	RKFCG
Hopper cars	RKFCH
Locomotives	RKLOC
Obligations	RFEO
Orders	RKFCOR
Refrigerator cars	RKFCR
Self-propelled cars	RKSPC
Stock cars	RKFCS
Tank cars	RKFCT

- o Equipment Statistics

Depreciation	RFDEPR
Dividends	RFDIV
Employee compensation	TCMP
Expenses, operating	RFOE
Investment	RINV
Investment return	RFRRPI
Income, operating	RFNOPINC
Income, ordinary	RFORDINC
Rent	RFNRENT
Revenue account	RFOR
Revenue, freight	RFGFR
Revenue, operating	RFORTOTC
Revenue, piggyback	RFGFRPB
Taxes	RFTAX

- o Operating Statistics

Companies	RKCO
Employees	RKEMP
Fuel used	RKFU
Fuel costs	RCACF
Rails laid	RL
Passengers	RTP
Rate increases	RCXPI
Road miles	RKRM
Ties laid	RKTL
Tons carried	RTTC
Track	RKTK
Train miles	RTFCML

- o Price and Cost Indexes

Cost indexes	RCCOP
Freight price indexes	RCPIRF
Spot price indexes	RCSP

TRUCK INDUSTRY

General Concepts

- o time series related to the U.S. intercity motor carrier operations. The majority of the information is related for for-hire regulated carriers, although selected data are financial and operating statistics of large Class I motor carriers (of property and household goods), truck and trailer sales (domestic and foreign), as well as vehicle registrations by state.

Sources & Data

o Bureau of Accounts Interstate Commerce Commission	- annual revenue and data on large Class I household goods and property carriers by 3-digit detail and quarterly income data by carrier.
o Motor Vehicle Mfg. Assn.	- monthly and quarterly data on factory sales of different motor vehicles by make and weight, from U.S. and Canadian plants; and new truck retain sales and stocks.
o Bureau of Census U.S. Dept. of Commerce	- monthly truck trailer shipments by type and exports by country.
o Federal Highway Administration Dept. of Transportation	- annual truck registrations.

The data files listed below are located in data banks that have the following code names: @TR/KB,@TR/KQ,@TR/KA

Series Prefixes

o Exports, Sales Shipments by Vehicle	
Buses	TKBUS
Trucks	TKTRK
Truck trailers	TKTRL
o Financial Series	
Freight revenue	TFGFR
Income, net	TRNINC
Operating income	TFNOPINC
Operating ratio	TFOR
Operating revenue	TFORTOT
Return on equity	TFROE
Revenue tons hauled	TTT
o Registrations	TKTRKREG

KEY INDICATORS

General Concepts

- a collection of series detailing manufacturing activity, bulk commodity production, sales and shipments, fresh fruit and vegetable loadings, and other related modal indicators. These series are used in the monitoring reports to monitor transportation activity.

Data Sources

- The Association of Home Appliance Manufacturers
  Major Home Appliance Factory Shipments

- Association of American Railroads
  Car Service Division, Statement CS-54A

- American Plywood Association
  Plywood Statistics

- Federal Reserve Board
  Industrial Production, G.12.3

- Motor Vehicle Manufacturers Association of the U.S., Inc.
  Factory Sales of Passenger Cars, FS-1

- Ore and Coal Exchange
  Report C-1, Statement of Bituminous Lake Coal
  Report O-1, Statement of Iron Ore Handled Over Stocks at Lake Erie Port
  Report O-1-L, Statement of Foreign Iron Ore Handled Over Stocks at Lake Erie Port

- U.S. Department of Agriculture
  Grain Market News

- U.S. Department of Commerce
  Current Industrial Reports, Manufacturers Shipments, Inventories and Orders, M3-1

- U.S. Department of Energy
  Bituminous Coal and Lignite Distribution Report
  Coke and Coal Chemicals

The data files listed below are located in data banks that have the following code names: @TR/MA,@TR,MQ,@TR/MM,@TR/MW

Series Prefixes

- Industry Indicators

Agricultural products	IND01
Chemicals	IND28
Coal mining	IND11
Crude oil	IND13
Electrical machinery	IND36
Iron ore	IND10
Lumber and wood products	IND24
Nonelectrical machinery	IND35
Petroleum and coal	IND29
Primary metals	IND33
Transportation equipment	IND37

o Other Indicators

Cars loaded	RTCL
Car utilization	UTIL
Coal transport rates	RC
Deliveries of coal	DCOALEU
Fertilizer shipment index	JSIND28
Industrial production index	JQIND
Production of coal	QBIT
Rail freight price index	JPRF
Revenue freight cars	RKFC
Sales of trucks	TKTRK
Shipments of coal	DBITLIG
Shipments of grain, barge	WRBS
Shipments of truck trailers	TKTRL
Truck tonnage	TTT
Waterborne tons	WTT

DRI REGIONAL INFORMATION SERVICE

The Regional Information Service provides up-to-date analyses and forecasts of economic and demographic activity for every state and region of the country and for selected metropolitan areas. The service is designed to provide a consistent and comprehensive perspective of the future economic conditions in each area of the country. The Regional Information Service is currently used by Corps navigation analysis units in their waterborne traffic demand forecasts, commodity forecasts, and impact-assessments of proposed waterway user fees. Complete historical and forecast data bases that directly support the models are included with on-line subscriptions.

Highlights of the Regional Information Service include: 2-digit SIC code level forecasts for manufacturing employment; End Market Flows - a regionalized input-output table of intersectoral purchases; SMSA forecasts of key economic and demographic conditions; and data derived by disaggregating reported data to ensure consistency among all states.

Annual subscriptions to the service are available for the entire United States or for any of the following broad regions of the country:

- Northeast (New England and Middle Atlantic)
- North Central (East and West North Central)
- South (South Atlantic, East and West South Central)
- West (Northern Pacific/Mountain and Southern Pacific/Mountain)

Forecasts provided by the service are based on a modeling approach that is consistent at all levels and has simulation capabilities. The model's region-by-region forecasts take into account the forces that affect each region's share of national output including the key interrelationships among regions.

All of the models and forecasts are available on-line for analyses and simulations. Special-purpose DRI software programs allow users to quantify and effectively compare and contrast the growth prospects of different areas of the country. This information can then be presented in graphs and reports.

The forecasts are also published in hard copy four times per year. Each issue provides timely commentaries on the factors that affect the outlook of a particular region, state or local area. The publications also contain an overview for all nine Census Divisions of the country, but only state and SMSA detail for those areas within one of the four broad regions. Forecasts are prepared quarterly. Two of these releases are short-term (10-12 quarters), the third extends to five years, and the fourth has a 10-year horizon.

Forecasts by region and state are available for:

- o Employment by 2-digit manufacturing, and six other categories
- o Income: personal and three other categories
- o Average hourly manufacturing earnings
- o Population for births, deaths, net migration, and total
- o Housing: single- and multi-family starts, stock, average sales price
- o Business tax burden

Forcasts for nine Census Divisions are provided for:

- o End market flows (29x29 sectors)
- o Price of electricity
- o Construction (selected categories of residential, nonresidential and nonbuilding)

SMSA forecasts are available for:

- o Employment by manufacturing and nonmanufacturing
- o Personal income
- o Population
- o All-urban Consumer Price Index
- o Mortgage rate
- o Total retail sales

DRI COST FORECASTING SERVICES

The U.S. Cost Forecasting Service forecasts detailed, disaggregated prices and wages based on analyses of industrial supply and demand.

In the cost forecasting models, supply is examined according to the stages of processing: each commodity price is analyzed in terms of the labor, material, and energy mix specific to its production process. Market conditions and external events - are also included in the analysis. Demand analysis is based on a rigorous delineation of end-use markets for each commodity, as well as careful identification of the variable relationship between market strength and price change. Statistical methods are used to identify weight the most significant external influences on price and to represent the timing of the supply and demand influences on price behavior. Forecasts are provided for over 250 producer price indexes; hourly earnings of construction workers and production workers in major SIC industries; facility cost indexes; transportation cost indexes; and selected consumer price indexes.

The DRI cost forecasts enable planners to:

- o develop budgets for fixed, variable, and overhead costs;
- o meet inflation cost accounting requirements;
- o study cost implications of materials substitution;
- o forecast cash flow requirements for construction projects and other capital investments;
- o negotiate fixed-price contracts and construct escalation clauses;
- o evaluate subcontracts and suppliers quotes;
- o optimize timing of purchases and anticipate inventory replacement costs.

The International Cost Forecasting Service extends the stages of processing methodology to include international trade and cost linkages, providing price and wage forecasting capabilities for over 100 European (France, Germany, the United Kingdom, and Italy), 30 Japanesse and 50 Canadian forecasts over a five-year horizon (ten years for Canada). These forecasts extend DRI's capabilities to provide:

- o budget projections for multinational operaticns;
- o procurement analysis involving imported materials;
- o evaluation of a product's future competitive position in world markets.

MAJOR DATA BASES

- o Comprehensive monthly data from the Bureau of Labor Statistics (BLS) on Producer Price Indexes, Consumer Price Indexes, Industry Price Indexes, and average hourly earnings by SIC code. Also, average annual salaries for several professional, technical, and clerical occupations, as well as quarterly import/export price indexes for 64 selected commodity groupings.
- o Engineering News-Record wage rates and manpower shortage indicators by construction trade by city.
- o Purchasing and Purchasing World monthly leadtime data on a wide variety of commodities.
- o Bureau of Mines and Department of Commerce monthly data on nonferrous metals. Data are available on production, inventories, imports, exports, and consumption of aluminum, copper, lead, nickel, tin, titanium, and zinc.
- o Commodity price indexes and industry labor rates for the United Kingdom, Canada, France, Italy, West Germany, and Japan.

U.S. NATIONAL AND REGIONAL DATA BANKS

The U.S. Central Data Bank is a large collection of financial, economic, and demographic historical data at the national level. The information includes: national income and product accounts data; retail sales, shipments, inventories, and orders; consumer and wholesale price indices; labor force, employment, hours, and earnings; housing starts and completions; Quarterly Financial Report and other industry data; financial and consumer credit data. All time series are updated immediately upon official release of the data. Data are drawn from numerous government and private sources. Among the government agencies which supply statistics are: the Federal Reserve Board, the Federal Trade Commission, and the U.S. Departments of Commerce, Labor and Treasury. Private sources of information include: Association of American Railroads, First National City Bank of New York, National Association of Realtors, and National Institute of Life Insurance.

The U.S. county data bank is a collection of over 200,000 annual time series covering the following concepts: employment by industry, personal income and components, and population by age and sex. Each concept is available for each of the 3,033 counties or equivalent areas in the United States. Data are generally available from 1965 forward. Personal income and employment series are provided by the U.S. Department of Commerce's Regional Economic Measurement Division of the Bureau of Economic Anlaysis on an annual basis. Population data are made available by the Census Bureau on a flow basis throughout the year.

The U.S. Model Data Bank contains quarterly historical data used to support DRI's macroeconomic model of the U.S. economy. The data, a subset of some 1,000 key indicators, are drawn largely form other DRI data banks including U.S. Central, U.S. Prices, Flow of Funds, Energy, and selected international data banks. Coverage extends to the following broad areas: consumer spending, government spending, foreign trade, employment and labor force, financial sector, construction and housing, automobiles, flow of funds, mortgage sector, industrial production and productivity, inventories, energy, business fixed investment, and prices and wages.

The U.S. Regional Data Bank contains indicators of economic activity in various states, regional and metropolitan areas. Information available includes: personal income and its components; labor force, employment, hours, and earnings; population and other demographics; consumer price indices; banking and financial indicators; government receipts and expenditures; housing permits and mortgage rates; manufacturing production (Annual Survey) and retail sales statistics. Data are available monthly, quarterly, and annually, SMSA, state, Federal Reserve district, and census region levels. Sources of information include various Federal agencies and Federal Reserve Banks. Additionally, DRI uses state-supplied data when they are more timely than those supplied at the federal level, and when they include data unavailable from federal sources. Federal sources include: U.S. Departments of Commerce, Labor, Transportation, and Treasury.

The U.S. Prices Data Bank is a massive collection of consumer, producer, and industry-sector price indices compiled by the Bureau of Labor Statistics (BLS) of the U.S. Department of Labor. BLS published these data in two monthly reports: The Consumer Price Index: Detailed Report and Producer Prices and Price Indexes. Most indices are not seasonally adjusted, although some seasonally adjusted consumer and producer price indices are available in the price data bank. Approximately 8,600 time series in the data bank are the published "all urban consumer price index (CPIU)" and the "revised wage earner and clerical worker index (CPIW)" and their components for the U.S. city average, 4 regions, 26 standard metropolitan statistical areas, 2 standard consolidated areas, and 5 city population size classes. Several thousand series in this bank are estimates of the producer price index by commodity and stage-of-processing, as well as industry-sector indices for the United States.

The Conference Board Data Bank is a unique source of proprietary data, both historical and forecasted, measuring activity in various sectors of the economy at the national level. The historical data include: surveys of consumer and business sentiment; capital appropriations, expenditures, cancellations, and backlogs for manufacturers and utilities; household budgetary patterns as reflected in discretionary spending, savings, and purchasing power; and measures of direct economic impact of the Federal budget. The forecasted data include: detailed forecasts by The Conference Board of all major GNP components, summary forecasts (GNP, inflation, unemployment rate) from eight major economic forecasting companies, consensus and sectoral forecasts of GNP components from prominent American economists, and forecasts of capital appropriations and expenditures by The conference Board. Access to The Conference Board data bank must be arranged by contacting the Board directly. The Economic Research Division of The Conference Board provides the information at these frequencies: annual, semiannual, quarterly, bimonthly, monthly and ten-day.

INTERNATIONAL TRADE DATA BANK

The Corps' Navigation Analysis Center, at the Institute for Water Resources, subscribes to the published reviews on the DRI International Trade Data Bank, and distributes the reviews to concerned Corps districts. The DRI International Trade product group is expanding and can now provide the Corps with import/export trade data by district of entry and country of origin/destination. The reviews contain data that are useful in deep draft navigational cost/benefit analysis and in the future, may be linked with Waterborne Commerce statistics data by five-digit Army Port Equivalent code. These data are monthly back to January 1981, and can be linked also to annual trade series C data to make a longer time series. Work that DRI is doing for the Maritime Administration may provide further assistance in determining vessel-specific transportation costs in Corps studies.

OTHER DRI DATA

Besides the four services presented here, there are numerous other DRI sources of data and projections available for Corps use. County-level business patterns, F.W. dodge construction potentials and the DRI energy and coal models represent samples of additional services. The DRI data and services are available to individual Corps districts which may contract with DRI for on-line access to data and forecasts or on-line consulting support by submitting a purchase order citing the applicable overall DOD/DRI contract. To initiate a usercode the on-line access. Corps users are advised to contact the Navigation Analysis Center as indicated on the first page of this section.

HARDWARE AND SOFTWARE REQUIREMENTS

The DRI data sources have the following hardware and software requirements:

- o Access to DRI timesharing system
- o Remote batch operations
- o Line printer (131 columns)
- o Input/output terminal (ASCII) with modem
- o Reference and user manuals

STRENGTHS

The DRI data sources and services have the following strengths:

- o The broad scope of the data banks, up-to-date nature of the DRI data, and large multidisciplinary staff are appropriately combined so as to provide to DRI clients a large menu of strengths. For most clients, the DRI services meet most of their requirements.
- o By the use of search parameters listed in libraries, subscribers may search the DRI data banks to retrieve information which satisfies their specific requirements.
- o DRI frequently conducts education and product seminars to expose clients to DRI's computer software programs, to DRI models, and to the theory of econometrics and statistics as the related to various applications. The focus of the seminars ranges from simple data manipulation to sophisticated model building. The goal of the seminars is to enable clients to use DRI's tools in their planning processes. Toward that end, the seminars emphasize time- and cost-saving techniques as well as pragmatic on-line applications of methodologies that are designed to help clients address their specific requirements.

WEAKNESSES OR LIMITATIONS OF USE

The DRI data sources and services have the following weaknesses or limitations of use:

- o Due to the non-customized nature of the Corps of Engineers contracts with DRI, Corps personnel may find that immediate access to DRI consultants is not always available.
- o Because DRI has made use of their banks easy even for non-data processing personnel, DRI encourages interactive use of its system; therefore, intricate queries may be unexpectedly expensive. To reduce the cost of routine queries, a user must make a special effort to find out how to implement deferred batch queries.

DATA FILE TITLE:	RAILROAD ONE-PERCENT SAMPLE WAYBILL DATA, 1969-1970 AND 1973-80
CODE NAME:	WAYBILL Data
COMPILER:	Office of Information and Statistics Division U.S. Department of Transportation Federal Railroad Administration Washington, DC 20590
LOCATION AND AVAILABILITY:	Data are stored sequentially on magnetic tapes on a Honeywell computer at the Engineer Automation Support Activity (EASA), and on a Burroughs computer at Data Resources, Inc. (DRI). Both EASA and DRI are operating out of offices in Washington, DC. By means of a Navigation Analysis Center (NAC) subscription with DRI, the data tapes are accessible to Corps personnel through a DRI Data Base Management System which services DRI clients. Under the NAC subscription with DRI, Corps personnel with a valid DRI account number may obtain copies of the data tapes through DRI or NAC. Other Corps personnel desiring to obtain copies of the data tapes are advised to contact the: Navigation Analysis Center Institute for Water Resources U.S. Army Corps of Engineers Casey Building Fort Belvoir, VA 22060 Attn: Mr. Francis M. Sharp Telephone Number: (703) 325-0574
DEVELOPMENT STATUS:	Completed for years shown in title above
DOCUMENTATION STATUS:	Completed for record layout only

DATA FILE DESCRIPTION

The railroad one-percent waybill or carload sample is a proportional sample of audited revenue waybills for carloads terminated by line-haul operating railroad (as distinguished from a switching and terminal company) having $3 million or more average operating revenues over a 3-year period and filed with the Interstate Commerce Commission. The waybill data includes import, export, transit, rebilled and piggyback (TOFC-trailer-on-flat-car) traffic. Excluded are traffic originating in Mexico and Canada and shipment weighing less than 10,000 pounds moving on less than carload (LCL) or any quantity rates.

OUTPUT DATA PROVIDED

Standard output reports are not available. To use the data, one must obtain access to the tapes and write his own reporting programs. Data on the tapes include:

- Serial Number
- Waybill Number
- Waybill date
- Terminating year
- Number of Carloads
- Car Initial
- Car Number
- Origin Railroad
- Origin Station
- Destination Railroad
- Destination Station
- Type of Rate
- STCC
- Weight
- Weight Units
- Revenue
- Origin location (state-county-point)
- Origin Rate Territory
- Destination location (state-county-point)
- Destination Rate territory
- Short-line territory
- AAR Car Type
- Tons
- Shipper Routing Indicator
- Number of Junctions
- Junction Railroad and Station
- TOFC Plan
- Number of Trailers
- Number of Containers

DATA FILE TITLE:	DEEP DRAFT VESSEL OPERATING COSTS AND CHARACTERISTICS
CODE NAME:	DVOCC Data
COMPILER:	Marine Management System, Inc. 102 Hamilton Avenue Stamford, Connecticut 06902
LOCATION AND AVAILABILITY:	Data file is published as a Corps of Engineers document, and is not accessible on-line. Data file is accessible and available in published form through the: Navigation Analysis Center Institute for Water Resources U.S. Army Corps of Engineers Casey Building Fort Belvoir, VA 22060 Attn: Mr. Francis M. Sharp Telephone Number: (703) 325-0574
DEVELOPMENT STATUS:	Completed
DOCUMENTATION STATUS:	Completed

DATA FILE DESCRIPTION

Deep Draft Vessel Operating Costs and Characteristics is a published data file consisting of operating costs, capital costs, vessel characteristics, and voyage characteristics for the United States and foreign flag deep draft vessels. It encompasses 1982 costs for the United States, German, United Kingdom, Japanese, Taiwanese and Greek operators. Voyage costs and characteristics are provided for four itineraries: one-way distances of 1,500, 2,500, 5,000 and 10,000 miles and basic drafts of 40 feet for U.S. ports and unrestricted draft in foreign ports.

OUTPUT DATA PROVIDED

The output data provided by the Deep Draft Vessel Operating Costs Report are:

- Annual vessel operating cost by vessel type and deadweight tonnage
- Vessel characteristics
- Voyage characteristics
- Voyage cost
- Cost per ton
- Time charter equivalent rates for new and secondhand vessel costs based on the following assumptions:
  - Seventy percent financing for 15 years at 15 percent
  - Current operating costs (manpower, insurance, provisions, repairs and miscellaneous) at no escalation
  - Zero taxes
  - 350 operating days per year
  - Residual value of a new vessel as assumed to be 25 percent of its original cost at the end of 15 years
  - Residual value of a secondhand vessel is assumed to be 10 percent of its purchase price

DATA FILE TITLE: RIVER POINT DIRECTORY FOR THE MISSISSIPPI RIVER-GULF COAST INLAND WATERWAY SYSTEM

CODE NAME: RIVER POINT Data

COMPILER:

Hydraulics Laboratory
U.S. Army Engineer Waterways Experiment Station
P. O. Box 631
Vicksburg, Mississippi 39180

LOCATION AND AVAILABILITY: Data are published by the U.S. Army Corps of Engineers, and are stored sequentially on magnetic tapes on a Honeywell computer at the Engineer Automation Support Activity in Washington, DC. Corps personnel desiring to obtain the published data and copies of the data tapes are advised to contact:

Navigation Analysis Center
Institute for Water Resources
U.S. Army Corps of Engineers
Casey Building
Fort Belvoir, Virginia 22060
Attn: Mr. Francis M. Sharp

Telephone Number: (703) 325-0574

DEVELOPMENT STATUS: Completed through the year 1977

DOCUMENTATION STATUS: Completed

DATA FILE DESCRIPTION

The River Point Directory is a quick-reference working document for use by engineers and planners in the general fields of river navigation and waterborne commodity movements. All navigable rivers, bayous, streams, and other such waterways in the Mississippi River-Gulf Coast region are included in this initial printing of the Directory. The rivers included in the Directory are, in general, listed in the order of their importance as commodity transportation arteries with regard to varying degrees of impact on the economic welfare of the United States. The Directory is, in essence, a compilation of significant data relating to each commercial dock, town, landing, navigation lock, bridge, junction, and other such river points contained in selected portions of the U.S. Army Engineer Waterborne Commerce Statistics Center (WCSC) Port and Dock Code Manual (Parts 2 and 3), dated 1 January 1973. Six other different types of reference documents were used to compile the information on each river point. The following information, when pertinent and available, was included in the Directory for each of the 7,425 river points listed.

- o WRSC port code
- o WCSC dock code
- o Point descriptive title
- o Horizontal and vertical bridge clearances to the nearest tenth of a foot
- o Performance Monitoring System (PMS) lock code
- o Point code
- o River code
- o River mile location
- o State code
- o County (or county equivalent) code
- o Business Economics Area (BEA) code
- o Standard Metropolitan Statistical Area (SMSA) code
- o Waterways Freight Bureau (WFB) tariff index
- o WFB junction index

All of the items above will be explained in detail in the section herein on output provided. When available, the horizontal and vertical clearances in feet to the nearest tenth were included for each bridge. Also, a special Corps Performance Monitoring System lock code was specified for each active lock listed in the Directory.

In the context of this report a "river point" is defined as a dock, landing, wharf, island, bridge, lock and dam, tributary junction, town, or other such water-related appurtenance along a river, canal, bayou, or similar navigable waterway. Most of the points in and adjacent to the Gulf of Mexico were considered to be associated with the Gulf Intracoastal Waterway (GIWW), the major navigable waterway along the southern coast of the U.S. The basic guide used to identify river points for this Directory was the U.S. Army Engineer Waterborne Commerce Statistics Center "Port and Dock Code Manual" (Part 2: Mississippi Valley-Gulf Coast Area and Part 3: Great Lakes Area). This Directory does not presently include all of the river points listed in these two WCSC manuals.

The primary purpose of the directory is to provide a means of relating waterborne commerce movement patterns, as compiled by the WCSC, to several different coding systems and categorizations that would be useful for projecting future waterborne traffic levels, for monetary rate analysis studies, and for planning studies of waterway improvements. A secondary objective was to simply provide a basic data file of river point information, e.g., state, county, river mile, etc., for use by various U.S. Army Corps of Engineers district offices.

OUTPUT DATA PROVIDED

WCSC Port and Dock Codes

The port code is a five-digit number that indicates a major geographical area of the United States; the district within the major area; and an individual port or section within a port, waterway or mile station. The dock code is a three-digit number which designates the dock, wharf, or pier within a port or at some specific point along a river.

In some cases, all points within a major river or coastal port or along a relatively minor tributary were assigned the same port code. In these cases, the dock numbers began at the designated river or port origin and increased progressively along the upstream right bank until a predetermined point such as a lock and dam or the end of the tributary or port was reached. From here, every point on the opposite bank was assigned a dock number, proceeding in the downstream direction until the point immediately upstream of the starting point was assigned a number. This procedure was repeated until all points along the waterway or within the major port were assigned a dock number.

River Point Descriptive Name

In most cases, the description in the WCSC manual was used. In some instances, the descriptive title of the juncture point at the beginning of each river was often expanded to more clearly identify the river on which the point data that followed would be applicable. For example, the WCSC description of the first point on the Monongahela River is "JCT OHIO RIVER." The descriptive title in this instance was expanded in the Directory to "JCT MONONGAHELA RIVER WITH OHIO RIVER." Minor revisions were also made to some of the other WCSC point names to more clearly identify them.

River Point Code

The river point groupings and associated two-digit codes used in the data base are given in Table 6. One of these codes was chosen for each river point in order to place them into general categories. The river points included in the coding list are sufficiently broad to allow expansion of this data base into a locational data base for general reference purposes. Each active lock was given the river point code "06" preceded by a two-digit lock code (data columns 48 and 49) from Appendix A of the PMS Data Collection Manual. Several locks listed in the PMS manual as being on the GIWW are actually located on tributary waterways and have been coded to reflect the proper waterway. The changes made to the PMS coding are shown below:

Lock Name	PMS River Code	PMS Lock Code	Actual River	Directory River Code	Directory Lock Code
Port Allen	GI	01	Port Allen to Morgan City Alt. Route	PA	01
Bayou Sorrel	GI	02	Port Allen to Morgan City Alt. Route	PA	02
Inner Harbor	GI	03	Inner Harbor Nav. Channel	IH	03

As shown, the assigned PMS lock code was maintained in each case; only the river code was changed to specify the waterway on which a lock is actually located.

Points on rivers and waterways are included in the WCSC coding manual primarily to reference a terminal point for a waterborne commerce movement. Many points reference a local temporary point, such as a fill or borrow area, and were, therefore, not indicated on the navigation maps. Points of a temporary nature were normally assigned the code "99."

As mentioned earlier, the channel constriction codes were not used in this initial effort. The point codes 11 and 12 were used to indicate the beginning and ending, respectively, of each major port. Major ports were considered to be those assigned beginning and ending mileage points in the WCSC manual and for which all river points within the port are assigned a single five-digit port code. The code "88" was used for points not contained in the navigation charts but which could be located using the encoded river mile and bank indicator of the WCSC Port/Dock Code. Obsolete locks which have been replaced by modern locks, but which are included in the current WCSC manual, were coded "88." Small towns where no dock was indicated on a navigation chart were also coded "88." The code "99" was used for points which could not be located using either a navigation map or the WCSC codes. If a point could not be found on a navigation chart, but the WCSC code was the same as another point, it was assumed that the point had been renamed and it was given the same river mile, county, etc., as the point that was found. The navigation charts furnished by the Corps district offices were found to be of varying detail and usefulness. For instance, many points along a river were included on some

TABLE 6

RIVER POINT CODES

Item	Code
Commercial dock	01
Landing or ramp	02
Wharf	03
Ferries	04
Foreign traffic only	05
Lock	06
Junction	07
Junction of a nonmaintained tributary	08
Bays, small connecting inland lakes	09
Beginning of a major port	11
End of a major port	12
Islands	15
Bluffs	16
Begin* right bend	21
End* right bend	22
Begin* left bend	31
End* left bend	32
Begin* channel constriction 2 way no passing	41
End* channel constriction 2 way no passing	42
Begin* channel constriction 1 way no passing	43
End* channel constriction 1 way no passing	44
Begin* channel constriction passing condition unknown	40
End* channel constriction passing condition unknown	45
Bridge - Type unknown	50
Bridge - Draw	51
Bridge - Lift	52
Bridge - Fixed	53
Bridge - Swing	54
Not found on navigation charts but identifiable through WSCS codes	88
Unknown	99

* Begin - upstream point; End - downstream point.

maps, whereas on others very few points were included. In the Gulf Coast area, the Corps no longer produces navigation charts. The charts available from the National Oceanographic and Atmospheric Administration do not show shore facilities. Therefore, most points on tributaries and coastal areas in the Mobile, New Orleans and Galveston Districts are coded "99." Plans are being made to secure the assistance of the district offices of the Corps to clarify these point codes.

River Code

The rivers listed in Table 7 have codes that are shown in the current Directory. The two-letter river codes of the PMS Data Collection Manual were used for rivers which contain navigation locks. The rivers which do not contain locks but which were assigned a separate block of tariff indices by the WFB were given newly developed codes. The points on the many coastal ports, bays and small bayous which are serviced by the GIWW were assigned GIWW tariff codes (when not assigned a separate block of tariff codes by WFB) and coded "GC" (for Gulf Coast) to distinguish them from points located directly on the GIWW.

River Mile

For most rivers in the Directory, there were three available sources for use in obtaining the river mile location of each point. First, and considered the most desirable, was the location of a point on a navigation map. It was then considered reasonably certain that the point really exists and that the river mile shown on the map was accurate. If a point could not be located on the map, but was listed in the WFB Tariff Index Pamphlet, then the river mile was taken directly from the WFB pamphlet. For some reason, however, many of the navigation chart mileages for the GIWW did not agree exactly with those in the WFB pamphlet. In any event, the navigation map mileages were used in this and all other cases, when available.

The third source of river mile data were the WCSC port and dock codes. As described above, the last three digits of the port code and the first digit of the dock code are actually the river mile (usually measured from the river mouth) for many points located along major rivers. In many cases, as explained above, the WCSC port codes were the same for all points within a major port or along a minor tributary, and thus, could not be used to determine river miles.

There were also a few inconsistencies in river origin points among the three available means for determining the river mile locations of points. For example, both the WFB tariff manual and the navigation charts computed Ohio River miles based on distances from Pittsburgh, whereas the WCSC manual codes originated mileage computations at the river mouth. Another inconsistency in river mile reference points involved the Ouachita River. The WFB tariff manual established the origin of this waterway on the Red River at Angola, Louisiana (junction of Red and Mississippi Rivers), whereas the navigation charts and the WCSC manual initiated mileage computations at the junction of the Black and Red Rivers (the Ouachita River flows into the Black River about 34 miles upstream from Angola). In these cases, the mileage reference point given on the navigation charts was used in the Directory.

TABLE 7

RIVERS INCLUDED IN RIVER POINT DIRECTORY

Allegheny River
Alabama and Coosa Rivers, AL
Apalachicola/Chattahoochee/Flint
Atchafalaya River

Bayou Terrebonne, LA
Bayou Barataria
Bayou LaFourche, LA
Blackwater River, FL
Bayou Teche, LA
Black Warrior and Tombigbee Rivers

Calcasieu River and Pass, Lake Charles, LA
Chicago Sanitary and Ship Canal
Channel to Aransas Pass, TX
Clinch and Emory Rivers, TN
Channel to Arroyo Colorado, TX
Corpus Christi Ship Channel
Channel to Palacios, TX
Channel to Rockport, TX
Calumet SAG Channel
Cumberland River

Freshwater Bayou

Green River and Barren Rivers, KY
Gulf Coast
GIWW
Gulf County Canal

Hiwassee River, TN
Houston Ship Channel

Inner Harbor Navigation Canal
Illinois Waterway

Kentucky River
Kanawha River

Lake Pontchartrain, LA

(Continued)

TABLE 7

RIVER INCLUDED IN RIVER POINT DIRECTORY
(Continued)

Matagorda Ship Channel, TX
Minnesota River, MN
Mississippi River Gulf Outlet
Mississippi River
McClellan-Kerr Arkansas River Navigation System
Monongahela River
Mermentau River Bayous Nezpique and Des Cannes, LA
Mobile Ship Channel

Neches River

Ouachita and Black Rivers
Ouachita River Above Camden, AR
Ohio River

Port Allen to Morgan City Alternate Route
Pearl River (East)
Pearl River (West)
Petit Anse Tigre and Carlin Bayous, LA

Sabine River and Harbor
San Bernard River, TX
St. Croix River, WI and MN

Texas City Channel
Tennessee River
Trinity River Channel to Liberty, TX
Tennessee-Tombigbee Waterway

Vermilion Bayou

Yazoo River Mouth, Vicksburg
Yazoo River, MS

The river miles for some points have been left blank (indicated in the Directory as "0"); for other points, the river mile "999.9" has been inserted. The original intent for this variation in the coding procedure was to leave blank the river mile for points on which the river mile might be determined in the future. The "999.9" coding would indicate that it was impossible to determine the river mile or that the river mile was not applicable, as in the case of docks along the Gulf Coast. Unfortunately, due to the voluminous size of the Directory, these standard coding rules were not always followed consistently during preparation of the data format sheets. Some of these data items will, therefore, be revised before the next printing.

State and County or County Equivalent Codes

In order to assign unquestionably accurate state and county codes, a river point had to be found on a navigation map, which, in most cases, clearly revealed both state and county boundaries. When points could not be located on a map, reasonable accuracy could be achieved in the assignment of some state and county codes through the use of the WCSC Port/Dock Code Manual. The encoded river mile (to the nearest tenth of a mile) would be obtained from the WCSC port and dock codes, which also include a code to indicate the side of a river on which a point is located. As explained earlier, if the last digit is a "1" the point is located on the right bank (when facing in the downstream direction); if it is a "2" the point is on the left bank. Thus, knowing the river mile and the bank, a navigation map could be used to determine the state and county of a point, even though it was not shown on the map. For example, if the WCSC code indicated the left bank at mile 196.1 and Wilson County, Ohio, borders the river on the left bank from mile 175 to mile 198, the county and state codes for Wilson County, Ohio, were recorded. Care had to be exercised in determining state and county codes, regardless of the procedure used, since a river often serves as a state and/or county boundary. After the names of the state and county were determined, FIPS Publication 6-2, "Counties and County Equivalents of the States of the United States," was used to assign the two-digit state codes and three-digit county codes shown in the Directory. Copies of FIPS Publication 6-2, or any of the other data source publications, are usually available from the publishing agency. For the points not associated with a single county and state, e.g., locks, bridges, etc., a "99" and a "999," respectively, were usually recorded as the state and county codes. In some cases, when a lock was clearly identified as being located in a given county, it was assigned that county's code.

BEA Code

The BEA code of a point was determined by locating the appropriate county on an available BEA map developed by the U.S. Department of Commerce. The BEA codes indicated on the map were used. BEA's for points along small rivers for which no detailed maps were available had to be approximated. Since BEA's are normally quite large, this posed little problem in most cases.

SMSA Code

SMSA's are listed by title in alphabetical order in FIPS Publication 8-3, "Standard Metropolitan Statistical Areas." The counties and county segments, if any, included within each SMSA are listed immediately following the SMSA title. Many counties, and thus the points within them, are not included in an SMSA. As a result, many river points are not assigned an SMSA code.

WFB Tariff and Junction Indices

WFB tariff indices are given in Section 5 of the WFB Tariff Index Manual for numerous points along the Nation's waterways. The assignment of a tariff index code to each river point was based on the exact or approximated river mile location of each point. For the WCSC points between WFB index points, the index associated with the adjacent lower mileage index point was used. For example, a dock located at mile 2.8 on the Allegheny River is recorded as index 1000, since index 1000 is at mile 0.0 and 1001 is at mile 3.5. In many cases, the tariff codes for major rivers were also used for tributary rivers which had not been assigned a specific block of tariff codes by the WFB. This implies that all points along a tributary are considered to be located at the junction point of the tributary with the major river, though in reality this, of course, is not the case. WFB junction indices were recorded only for junction points involving major rivers (River Point code 07), unimproved rivers (code 08), and bays and lakes (code 09). It should be noted that the junction index assigned to some small waterways, such as some of the southern bayous and small rivers, does not always coincide precisely with the mouth of the minor waterway. Such indices may, in fact, relate to a point along the bayou or small river several miles from the junction (or mouth). A junction index of this type represents the closest significant point to the junction and was used because an index for the river mouth itself was not specified by the WFB. Some noteworthy observations and approaches taken during the assignment of tariff and junction indices follow:

- For the junction of three major rivers at the same point, the WCSC manual lists only one of the two junction points. An additional junction point was therefore recorded in the Directory to indicate the junction of a specific river with a second river. In the case of the Monongahela River, for example, only a WCSC code and description for its junction with the Ohio River is given in the WCSC manual. Since the Allegheny River also junctions with the Monongahela River at this same location, an additional junction point having the same WCSC code as that given for the junction with the Ohio was therefore included in the Directory under the descriptive title "Junction Monongahela River with Allegheny River," and the junction index for the Allegheny River was recorded. The same procedure was used for the Allegheny and Ohio Rivers. In future commodity origin-destination studies, this will enable the computer to handle commodity tonnage movements between the Monongahela, Allegheny and Ohio Rivers. This double coding for junctions of three rivers has been accomplished only for major rivers.

Only those junction points listed by WCSC were used for the small bayous, etc., where, in some cases, three of them might junction at a point to form still a fourth bayou or river.

- Junction points of major rivers with small unimproved tributaries, gulfs, bays, lakes, gulf ports, and the like were simply assigned a junction index identical with the WFB tariff index. This, in essence, means that there is a junction at that point, but, at this time, due to the lack of sufficient information, all other points on the tributary are assumed to be located at the junction point also. In origin-destination commodity movement studies, all tonnage originating or terminating at various docks along the tributary would be assumed to have occurred only at the junction points. The tonnage moving on the small tributary would simply be considered as part of the tonnage moving on the major tributary.

- Points on bayous, canals, small rivers, harbors, etc., along the southern coast were assigned GIWW tariff and junction indices if such points had not been assigned a distinct and separate block of indices by the WFB. Such points were coded "GC," as mentioned earlier. For example, Bayou Bonfouca, Louisiana, is included in the WCSC manual (and thus in the directory under the New Orleans District), but no specific block of WFB tariff indices is assigned to this minor waterway. Therefore, as an alternative, Bayou Bonfouca, and numerous other small bayous, were assigned tariff indices associated with the GIWW, for which a separate block of indices was, of course, designated by WFB. On the other hand, Bayou Teche and other relatively significant waterways were considered important enough by the WFB to be assigned a separate block of tariff indices. Such waterways were assigned a separate river code as shown in Table 8.

- A few WFB indices were apparently incorrect. Those observed include.

  - <u>Ohio River</u>. The tariff index given for Fort Thomas, located at river mile 462.9, is 14,262. This is probably a typographical error; therefore, the index used in this case was 12,462 to continue the consistent sequence of encoded river mile indicators.

  - <u>Lower Mississippi River</u>. The tariff indices given for Violet and Meraux are 8041 and 8047, respectively. Since these points are at miles 84.1 and 87.0, respectively, the correct indices apparently should be 8084 and 8087.

  - <u>Inner Harbor Navigation Canal (IHNC)</u>. The IHNC junctions with the Lower Mississippi River at mile 92.6 and is listed in the Directory with a junction index of 8092. However, its junction index is listed by WFB as 8098 in the separate block of indices for the IHNC contained in the GIWW-East Index list.

TABLE 8

DATA SOURCE REFERENCES FOR RIVER POINT DIRECTORY

Title of Reference	Prepared by	Data Extracted
WCSC Port and Dock Code Manual, 1 Jan 1973	WCSC	WCSC river point identification code and brief description
River Navigation and Port Charts/Maps	Various Corps District offices	River point, type, river mile, and the state and county location of river points
FIPS Publication 602, Counties and County Equivalents of the States of the U.S.	National Bureau of Standards, U.S. Dept. of Commerce	State and county (or county equivalent) codes
BEA map (County Boundaries as of 30 Sep 1969, Area Names updated Mar 1972)	Regional Economics Division, Bureau of Economic Analysis, U.S. Dept. of Commerce	BEA codes for county (or county equivalent) in which a river point is located
FIPS Publicaton 8-3, Standard Metropolitan Statistical Areas (SMSA), dated 15 August 1973	National Bureau of Standards, U.S. Dept. of Commerce	SMSA code for the county in which a river point is located, if applicable
WFB Tarrif Index Manual (Section 5)	Waterways Freight Bureau, Room 844, 425 13th Street, N.W., Washington, D.C. 20004	WFB tariff index code
PMS Data Collection Manual, Appendix A	U.S. Army Corps of Engineers	River code for rivers on which Corps navigation locks are located, and PMS lock code

COMMENTS ON USE

Each year the U.S. Army Corps of Engineers publishes two documents that identify ports along the inland waterways of the United States. The Waterborne Commerce Statistics Center of the United States identifies major ports as defined by state and local governments, while the Port and Dock Code Manual is a comprehensive list of river points on the waterways. Using the Port and Dock Manual as a guide, the Corps' Waterways Experiment Station has compiled the River Point Directory for the contiguous Mississippi River system and Gulf Intracoastal Waterway. The Directory provides the Corps planners with a unique geocoding system that serves as the basic location reference for all inland navigation systems analysis, and as a cross reference among the directory codes and other geographic and indicators that are used to trace commodity movements by water and other modes of transportation.

To avoid confusion between the "ports" or "major ports" as already defined, the term "port equivalent" was coined to describe a composite of port characteristics necessary for waterway simulation. The major ports of the Waterborne Commerce Statistics Center of the United States exclude many significant ports and sometimes group diverse and extended river segments within a single major port. Conversely, the Port and Dock Code Manual and River Point Directory are of such detail that there would be a prohibitively large number of ports for the analyst to comprehend. A new definition was needed for purposes of inland navigation systems analysis on a national scale. Each port equivalent has been defined so that a complete set of port equivalents will span the <u>entire</u> inland waterway system as found in the River Point Directory. Actual waterway charts were utilized to determine homogeneous river navigation characteristics which may also influence the delineation of a port equivalent boundary.

The river mile location of the port equivalent will correspond with the geographic centroid of a major port segment; where several small ports are used to construct a port equivalent, the geographic centroid is weighted toward the larger volume ports. For the river miles of port equivalent boundaries, refer to the River Point Directory.

LIMITATIONS OF USE

The initial effort did not include in the Directory all the river, lake and coastal points currently coded by WCSC. Though an overwhelming majority of the WCSC coded points in Parts 2 and 3 of the Port and Dock Code Manual are included, the Directory is currently limited to those points associated with the Mississippi River navigation system (including all major tributaries) and the GIWW (including many of the numerous small streams and bayous which flow into the Gulf of Mexico along the southern coast). Specifically, all waterways under the jurisdiction of the U.S. Army Engineer District, Jacksonville, and many docks and other points in the Great Lakes area are not included at this time. The Great Lakes area points included to date are those along the Illinois Waterway (WCSC port codes 77000 to 77291), and those associated with the Calumet Harbor and River, Lake Calumet, and Calumet SAG Channel, Chicago Sanitary and Ship Canal, the Chicago River South Branch, the Chicago River Main and North Branches, and the Chicago Harbor (WCSC Port Codes 77641-77647). None of the points in Parts 1 and 4 of the WCSC Port and Dock Code Manual (Atlantic and Pacific areas, respectively) are currently listed in the Directory.

DATA FILE TITLE: BARGE LINE-HAUL RATE STUDY (U.S. Army Corps of Engineers Publication)

CODE NAME: BARGRATE Data

COMPILER:

Brown Associates, Inc.
6405 Danville Court
Rockville, MD 28052

LOCATION AND AVAILABILITY: Data file does not currently have on-line accessibility; however, the data file is published by and is available through the:

Navigation Analysis Center
Institute for Water Resources
U.S. Army Corps of Engineers
Casey Building
Fort Belvoir, VA 22060
Attn: Mr. Francis M. Sharp

Telephone Number: (703) 325-0574

DEVELOPMENT STATUS: Completed

DOCUMENTATION STATUS: Completed

DATA FILE DESCRIPTION

The barge rate study is the first cycle in a recurring program to obtain data on line-haul barge rates. The objectives of the program are to: (1) obtain estimates of line-haul rates by origin-destination combination for each of many classes of commodities; and (2) determine the influence of season and contract type on line-haul rate. During 1981, the Corps of Engineers initiated the program by conducting a study of the barge rates charged for various commodity classes moved on the inland waterways. A sample of approximately 4,000 movements was selected from shipments made in 1977. However, budgetary limitations necessitated stopping the data collection after inquiries were made concerning 1,700 movements. Because of a variety of survey execution problems, useful data were obtained for approximately 1,200 of the 1,700 movements. A major component of the study is a regression analysis that shows the relationship between line haul rates and river miles for a number of commodities. The regressions were developed from a data base of line haul rates charged during calendar year 1977. Therefore, the rates derived from the regression analysis cannot be used to estimate current line haul rates without adjustment for price changes since that time. Due to the fact that only approximately 1,200 questionnaires were tabulated out of the 4,000 selected for the sample, the data base for some commodity classes was too small to be used for calculation of reliable regression equations.

OUTPUT DATA PROVIDED

Line-haul barge rates.

DATA FILE TITLE:	INLAND WATERWAY VESSEL OPERATING COSTS (U.S. Army Corps of Engineers Publication)
CODE NAME:	INVOC Data
COMPILER:	Navigation Analysis Center Institute for Water Resources U.S. Army Corps of Engineers Casey Building Fort Belvoir, VA 22060 Attn: Mr. Francis M. Sharp Telephone Number: (703) 325-0574
LOCATION AND AVAILABILITY:	Data file does not currently have on-line accessibility; however, the data file is published by and is available through the compiler above.
DEVELOPMENT STATUS:	Completed
DOCUMENTATION STATUS:	Completed

DATA FILE DESCRIPTION

The Inland Waterway Vessel Operating Costs is an annual survey or update of towboat and barge costs for vessels moving on the Mississippi/Gulf Waterway System. It covers investment, fixed and operating costs according to vessel type, size and horsepower. This annual survey is distributed by the Institute for Water Resources, Navigation Analysis Center.

OUTPUT DATA PROVIDED

Towboat	Barge
Investment cost	Investment cost
Service life	Service life
Rate of return	Rate of return
Administrative expense	Administrative expense
Insurance	Insurance
Average operating costs (annual)	Annual operating costs
Hourly operating cost	Hourly operating cost

DATA FILE TITLE:	PHYSICAL CHARACTERISTICS OF INLAND WATERWAYS (U.S. Army Corps of Engineers Publication)
CODE NAME:	INCHAR Data
COMPILER:	Navigation Analysis Center Institute for Water Resources U.S. Army Corps of Engineers Casey Building Fort Belvoir, Viriginia 22060 ATTN: Mr. Francis M. Sharp Telephone Number: (703) 325-0574
LOCATION AND AVAILABILITY:	Data file consists of three data sets which do not currently have on-line accessibility; however, the data file is published by and is available through the compiler above.

DEVELOPMENT STATUS:	Lock Data Set:	Completed
	Channel Data Set:	Completed
	Bridge Data Set:	Completed
DOCUMENTATION STATUS:	Lock Data Set:	Completed
	Channel Data Set:	Completed
	Bridge Data Set:	Completed

DATA FILE DESCRIPTION

This data file (Physical Characteristics of Inland Waterways) was developed as an outgrowth of the Corps' INSA program which perceived the requirement of having readily accessible information on the physical characteristics of the locks, channels and bridges of the Nation's inland waterways. The nature and objectives of the INSA program are covered in detail in Chapter I of this report. This data file contains files on three categories of information: locks, channels and bridges. The three data files are used as basic input for the models which are also discussed in Chapter I.

OUTPUT DATA PROVIDED

The data base has three output data files which are described as follows:

Physical Characteristics of Locks

Output data in this file are reported in a format containing 50 different data columns which are described below:

- o Port-Dock Number
- o Lock Name
- o Waterway Name
- o Location (Mile)
- o Chamber Number: Where there is more than one chamber, each lock chamber is numbered, starting the numbering by designating the landward lock as No. 1 and proceeding in ascending order riverward. For instance at Louisville, Kentucky the existing 500 foot lock (most landward) is No. 1; the old 360 foot lock is No. 2 and the 1,200 foot (most riverward) lock is No. 3. (This number also gives the data base information as to the number of chambers at any one point.)
- o Year Operational
- o Pool Elevations (Normal Upper and Normal Lower)
- o Pool Elevation (Navigation Stops): The upper pool elevation is given for the point at which navigation stops. However, for some locks in the Mobile District elevation is that of the lower pool.
- o Pool Elevation (Lift): Lift is lift at normal pool stage or maximum lift if the maximum lift occurs a significant percent of time.
- o Dimensions (Length and Width)
- o Lock Elevations (Upper Sill, Lower Sill and Top of Walls)

- Vertical Overhead Clearance: At locks that have overhead bridges, such as New Cumberland and Pike Island locks on the Ohio River, the vertical clearance between low steel of the bridge and the river stage where navigation ceases is recorded.

- Gate Types (Upper and Lower)

- Emergency Closure Gate Type:

- Location of Approach Points (Upper and Lower)

- Upper and Lower Approach Walls (Elevation, River Length, Middle Length and Land length): The length of the approach walls is recorded. In each instance the length is measured from gate pintle (or similar point for other gate types) to the outer end. Note that two adjacent locks separated by a middle wall have different middle approach wall lengths and they are dependent on the locations of the gate pintle.

- Type of Filling System

Physical Characteristics of Channels

Output data in this file are reported in a format containing 30 different data columns which are described below:

- Official waterway name or designation

- Two-letter river code

- Segment number

- Segment reach descriptions

- Port-dock codes

- Segment reach by river mile

- Segment length

- Ratio (to tenths) of the main sailing line distance to the straight line distance from the beginning to the ending points of the segment

- Type of segment

- Average number of non-navigation days due to inclement weather

- Location of segment's main gauge

- Average annual current velocity at the main gauge

- Standard low water level

- Standard high water level
- Average volume in cubic yards of dredged materials taken from the segment based upon the average of the past five years.
- Total length of the dredged channel within the segment
- Predominant type(s) of dredged materials
- Average annual costs (over the past five years) for both maintenance and initial costs of river training works, provided project controlling dimensions remain the same
- Description and location of important non-delimiting structures and obstacles within the segment

Physical Characteristics of Bridges

Output data in this file are reported in a format containing 30 different data columns which are described below:

- Official waterway name or designation
- Two-letter river code
- Bridge number (two sets of codes)
- Official or preferred bridge name
- Descriptive location of bridge
- Distance in miles to the nearest tenth of a mile from the beginning reference point of the river, canal, or other waterway on which the bridge is located.
- Name(s) of the owner(s) of the bridge
- Year when construction was completed (year built)
- Type of bridge
- Type of traffic on the bridge
- For movable bridges only the following data are given:
  - season (months of operation)
  - hours of operation
  - advance notice requirement
  - official or agency authorized to receive advance notice
- Opening time (time, in minutes and tenths of a minute, required to open the bridge)

- Indication of the presence at the bridge of a radio telephone and/or a standard telephone

- Length of the "straight channel approach" to the bridge

- Channel maximum current velocity (miles per hours) that occurs within 1,500 feet of bridge during the navigable period

- Number of spans crossing the navigable channel

- Horizontal clearance(s) of the span(s) over the navigable channel

- Minimum vertical clearance at the standard low water level

- Minimum vertical clearance at the "2% line"

- Physical conditions and their durations in percent of a year for "limited navigation" and "complete cessation of navigation", based on the total years of record

GLOSSARY

ACCESS LINKS: In multimodal network terminology, access links represent those transportation operations needed to move freight shipments from the shipper's dock to a point of access to the line-haul transportation network, and from the network to the dock of the consignee.

AGGREGATE PORT EQUIVALENT (APE): An aggregate port equivalent is a combination of two or more port equivalents. The fewer port equivalents there are in a system, the less costly the running of a simulation program becomes.

APE: See AGGREGATE PORT EQUIVALENT.

APPROACH: Travel of a tow from the approach point, or from a point on the lock guidewall clear of the lock gates in the case of a turnback approach, to a point where the bow of the tow is abreast of the lock gates and tow is parallel to the guidewall ready to enter the lock chamber.

APPROACH POINT: The closest point to a lock at which one tow can safely pass another tow traveling in the opposite direction. Tows may not normally proceed beyond the designated approach point of a lock without the permission of the lockmaster.

AUXILIARY CHAMBER: A chamber of a multiple-chamber lock which is usually smaller and used less than the main chamber. Auxiliary chambers are normally used to pass small tows, light boats and recreational vessels, and to maintain navigation during periods when the main chamber is shut down.

BARGE: A non-self-propelled, usually flat-bottomed vessel, used for carrying freight on inland waterways.

BARGE AVAILABILITY FACTOR: The fraction of the time the barges are available for operational use after allowing for maintenance, servicing, etc.

BARGE BLOCK COEFFICIENT: A factor representing the shape of the barge. It is used in the speed function calculation and in the computation of the barge capacity factor. (See BLOCK COEFFICIENT.)

BARGE CLASSES: The definitions and descriptions of the types of barges. Each class of barge is described in terms of its type, its dimensions, the amounts of various commodity classes (cargo) it can carry, its draft (feet) empty and fully loaded to its maximum capacity, its area of operation, and a sequential identification number assigned to its class.

BARGE CLASS DESIGNATION BY COMMODITY CLASS: The use of the barge class designation control to define (restrict) the commodity classes that are allowed to be transported in each class of barge. Loading capacities are specified for each class of barge.

BARGE DRAFT: The barge draft (feet) when empty and also when fully loaded (to its maximum capacity).

BARGE FIXED OPERATING COST: The annual fixed cost of owning a barge, in dollars per year.

BARGE PICKUP/DROPOFF TIME: The average time, in minutes, for a tow to stop at a port and drop off and/or pick up barges.

BARGE PICKUP AND DROPOFF DELAY: Represents the time in hours-per-barge to configure a barge group for pickup by a towboat.

BARGE REGISTRATION FEE: The annual barge registration fee, in dollars per kiloton.

BARGE VARIABLE OPERATING COST: The variable component of barge operating cost in dollars per operating hour.

BEAM: The width of a vessel at its widest point.

BEA REGION: One of 173 geographic areas in the Unitea states delineated by the Bureau of Economic Analysis of the Department of Commerce.

BIT: The smallest unit of data tha can be stored in a computer. Bit is a contraction of the words "binary digit" and is symbolically represented by the number "0" or "1".

BLOCK COEFFICIENT: The ratio of the actual displacement of a vessel to the product of its length, beam and draft.

BULK COMMODITY: A good which is normally transported without the use of wrappers, cartons, containers or other packing.

BYTE: See CHARACTER.

CACI GENERATOR: The CACI WAM shipment generating program, written in SIMSCRIPT. It was designed to produce four seasonal, 45-day shipment lists when annual commodity flows are input. "Shipment factors" giving the percentage of annual tonnage moving in each season (winter, spring, summer, fall) for each commodity must be provided.

CALIBRATION OF MODELS: See STEADY STATE.

CANALIZATION: Creation of a navigable waterway by construction of locks and dams, river training works, new channels or canals, and combinations of these.

CHAMBER: The part of a lock enclosed by the walls, floor, sills and gates; the part of a lock within which the water level is changed as vessels are raised or lowered. A lock may have more than one chamber, and they may be adjacent or laterally separated.

CHAMBER CAPACITY PER YEAR: The number of nominal barges per year.

CHAMBER CLASS NUMBER: A number assigned sequentially to identify the chamber class.

CHAMBER DELAY PARAMETER: The average delay time, in minutes, at 50 percent of chamber capacity.

CHAMBERING: That part of a lockage cycle starting at the end of the entry and ending when the exit gates are fully recessed, or when the bow of the exiting vessel crosses the lock sill, whichever is earlier. Chambering includes closing the entry gates, filling or emptying the lock chamber, and opening exit gates.

CHARACTER (BYTE): A string of bits representing a letter, number or special character. The term "character" is synonymous with the word "byte". The two words may be used interchangeably. The number of bits in a byte depends on the architecture of a computer.

CHARTER FIXTURE: Information that should be invariably present in a mercantile lease of a ship or some principal part of a ship. A charter fixture may be a time fixture or a voyage fixture. See TIME FIXTURE and VOYAGE FIXTURE.

COAST GUARD EXPENDITURES: Opertion, maintenance and rehabilitation expenses for Coast Guard navigation aid, etc., in thousands of dollars per year.

COFC: Container on flatcar.

COMMERCIAL TOW AVAILABILITY FACTOR FOR THE AUXILIARY CHAMBER: The factor indicating the amount of time that the auxiliary chamber is available for use by commercial tows.

COMMERCIAL TOW AVAILABILITY FACTOR FOR THE MAIN CHAMBER: The factor indicating the amount of time that the main chamber is available for use by commercial tows.

COMMODITY AVERAGE VALUE: The average value, in dollars per ton, of cargo represented by commodity class. This factor is calculated as an average of included cargo values weighted by amounts shipped.

COMMODITY CLASS: A commodity class is an aggregate of commodities that usually have similar physical characteristics. A specific commodity class, however, may contain only one commodity. Each commodity class is defined in terms of the types of barges which may carry the commodity class, the density of loading of the commodity class, and whether or not the commodity class is considered hazardous cargo. (No tow containing hazardous cargo may be locked through with any other vessel.)

COMMODITY CLASS NUMBER: The number that is sequentially assigned to a class of commodities that have common identifying characteristics. Each cargo would have a commodity class number.

COMMODITY DENSITY: The average density, in pounds per cubic foot, of cargo in the commodity class. This is used in calculating barge capacities.

COMMODITY DESCRIPTION: The name of a commodity class.

COMMODITY FLOW: The shipment (movement) of a given commodity between a pair of ports.

COMMODITY FRACTION DEDICATED: The fraction (0.0 to 1.0) of the tonnage of a particular commodity class which is carried in dedicated tows.

COMMODITY GROUP: An aggregate of commodity classes. Commodity classes are aggregated into a commodity group to reduce the amount of computer storage required. Commodity groups are also used to assign handling rates to all commodity classes contained in a commodity group.

COMMODITY HOLDING COST: The effective annual cost of holding cargo while it is in the transportation process, including cost-items that are attributable to spoilage, in transit damages, security measures to protect the cargo, and most importantly, a loss of return (rate of interest) on capital invested in the cargo while it is unavailable for use during shipment.

COMMODITY MOVEMENT: See COMMODITY FLOW.

COMMODITY QUANTITY: The total tonnage (in kilotons) of a specified commodity class to be shipped during a specified season from an origin (port) to a destination (port).

COMMON CARRIER: A transportation company which serves the general public by hauling traffic as offered, without discrimination, over regular and irregular routes.

CONTRACT CARRIER: A transportation company which hauls traffic only under specific contract, and does not hold itself out for hire to the general public.

COST RECOVERY LEVEL: The desired fraction (0.0 to 1.0) of (A) government operation, maintenance and rehabilitation (OM&R) costs, and (B) government project implementation costs to be recovered through waterway user charges.

COVERED HOPPER BARGE: A barge similar in construction to an open hopper barge, fitted with watertight covers over the entire cargo hold.

CUT: A segment of a tow which is put through a lock separately from other segments of the tow, or the operation of a chamber to process that segment.

DATA BANK: A group of logically related data files or data bases.

DATA BASE: One or more logically related data files that have a defined structure and built-in update, query and retrieval mechanisms.

DATA ELEMENT: A string of related characters that are required to store a particular unit of information which provides the attributes for an entity. Attributes characterize or describe an entity.

DATA FILE: A group of logically related records which describe the elements comprising the group.

DECK BARGE: A barge consisting of a simple box hull and a heavy plated, well supported deck.

DEDICATED EQUIPMENT TOTAL: In the context of the INSA models, the total number of towboats and barges that are flagged (coded) with dedication index numbers which reserve them for exclusive use in the transportation of similarly flagged dedicated shipments. The appropriate dedicated equipment total can insure delivery of shipments originating or terminating near end points of a system, and can also aid in getting all tonnage shipped to and from tributaries. Models tend to neglect such shipments if they are not dedicated.

DEDICATED SHIPMENTS: Repetitive high-volume flows which move by towboats and barges that are dedicated to a single use. Typically, these movements are a shuttle type of operation with towboats traveling back and forth between a pair of ports, moving cargo in one direction and, most likely, empty barges in the other direction. (See DEDICATED TOW TRAFFIC.)

DEDICATED TOW: A tow composed of a towboat and barges that always stay together and are operated as a unit, and which in their operation are restricted to specified commodities and/or specified ports.

DEDICATED TOW TRAFFIC: The situation that stems from allocation of specified towboats and barges to use exclusively in delivering one or more designated shipments, and/or to operation exclusively on designated sectors. Typically, dedicated tow traffic is a shuttle type of operation with towboats traveling back and forth between a pair of ports, moving cargo in one direction, and most likely, empty barges in the other direction. (See DEDICATED SHIPMENTS.)

DELAY TIME: The time elapsed from the arrival of a vessel at a lock to the start of its approach to a lock chamber; the time spent in queue awaiting lockage.

DESTINATION PORT: A port at which a given cargo is to be delivered. (See PORT.)

DOUBLE LOCKAGE: The type of lockage performed when a tow is passed through a lock chamber in two segments or "cuts."

DRAFT: The depth of water displaced by a vessel.

DRY TIME FIXTURE: See TIME FIXTURE.

DRY VOYAGE FIXTURE: See VOYAGE FIXTURE.

ENTRY: That part of a lockage cycle starting at the end of the approach and ending when the tow or cut is secured within the chamber and the gates are clear, or when the closing of the gates has been initiated, whichever is earlier.

EQUALIZE QUEUE LENGTH: A lock operating policy in which the next vessel to be locked through is selected from the longer of the queues on the upstream and downstream sides of the lock.

EQUIPMENT TOTAL: The total number of towboats and barges in a system.

EXCHANGE APPROACH: The type of approach executed when the vessel inbound to the chamber passes a vessel outbound to the chamber.

EXCHANGE EXIT: The type of exit executed when the vessel outbound to the chamber passes a vessel inbound to the chamber.

EXEMPT CARRIER: A transportation company which would normally be considered to be a common or contract carrier, but which is specifically exempted by statute from the economic regulatory features of the Interstate Commerce Act.

EXIT: That part of a lockage cycle starting at the end of a chambering and ending when the lock has completed serving a vessel or cut and can be dedicated to another vessel or cut.

EXTERNAL EVENT INPUT DATA: Input records that are read into the Waterway Analysis Model (WAM) during the simulation process, and which trigger occurrence of events. There are two types of external event data: 1) shipment data, and 2) run control data.

FIRST-COME-FIRST-SERVED: A lock operating policy in which vessels are selected for service in the order in which they arrived at the lock, irrespective of travel direction; often abbreviated FCFS.

FIRST-IN-FIRST-OUT: Same as FIRST-COME-FIRST-SERVED; often abbreviated as FIFO.

FIRST PORT: The first port of a selected pair of ports. Note that various reports will reflect movements in both directions between the two ports, therefore, the first port is not necessarily the original port of origin.

FLEETING AREA: A location on a waterway where tows are assembled and disassembled, or where the configuration of a tow is altered.

FLEETING OPERATIONS: Operations that transfer barges among towboats. Barges can be picked up or dropped off by a towboat, only at a PE or APE.

FLEETING POINT: A port that serves as a fleeting area for tows. It must be located at a network junction, that is, it must be connected to a network junction by a zero-length link. A port may be both a fleeting point and a shipment terminal.

FLOTILLA: A towboat with its barge(s).

FLOTILLA MODEL: The predecessor of the Tow Cost Model (TCM).

FLY APPROACH: The type of approach executed when the lock has been idle and the inbound vessel proceeds directly to the chamber.

FLY EXIT: The type of exit executed when the lock will be idle following the departure of the outbound vessel, that is, when no vessels are awaiting lockage.

FORTRAN IV: A version (level) of a computer programming language (FOR(mula) TRAN(slation)) that was developed specifically for programming (coding) mathematical and scientific problems for solution by an electronic computer.

HANDLING CLASS: The identification of one of three classes of cargo relative to cargo-handling facilities at ports (1 = dry large granular bulk and packaged cargo, 2 = dry fine-grained bulk cargo, and 3 = liquid cargo). Cargo is described by transportation class and by handling class.

HANDLING RATE: See LOADING/UNLOADING RATE.

HELPERBOAT: Any boat which helps a tow move through a lock.

IMPLEMENTATION EXPENDITURES: Government costs for new projects construction in a specified river segment, expressed in thousands of dollars per year. These expenditures vary greatly from year-to-year, therefore, multiyear averages are typically used.

INCLUSION ELLIPSE: In the multimodal context of the Transportation Freight Model (TFM), the inclusion ellipse, in effect, constitutes a path (route) circuitry constraint which greatly reduces the amount of computer processing time required by the path selection algorithm. As the number of allowable routes between origin-destination pairs is potentially large, route selection is limited by five classes of constraints. The five classes are route constraints, mode constraints, capacity constraints, inertia constraints, and path circuitry constraints. The location of each node is given in terms of geographic coordinates. Then an ellipse of a given eccentricity is constructed about the origin and destination regions for a particular shipment, with the major axis of the ellipse being the straight line connecting the centers of the two regions. The path selection algorithm then considers only those routes, between the two regions, that lie totally within the ellipse. The algorithm permits the ellipse to automatically increase in size, according to specified criteria, to insure that at least one route is included.

INERTIA EFFECT: In transportation system terminology, the inertia effect is the condition attributable to groups of factors that limit the response of shippers to competitive forces in the transportation market. Included in the group are factors such as: The long-term nature of many commodity shipping arrangements (contracts) between a shipper and a carrier, which effectively removes that shipper's goods from the arena of intermodal competition for the duration of the contract; reluctance of shippers to alter existing procedures, making them insensitive to small intermodal cost differentials; and investments by shippers in long-lived capital goods designed to interface with only one transportation mode.

INSA: Inland Navigation Systems Analysis (Program).

INTEGRATED TOW: A tow consisting of a lead barge with a raked bow and a square stern, a number of intermediate double square-ended barges, and a trailing barge with a square bow and a raked stern.

JACKKNIFE LOCKAGE: A type of lockage in which the tow is rearranged, usually from two barges wide to three, by breaking the face coupling on at least one barge and knockout of the towboat.

JUMBO BARGE: A barge 195 feet long and 35 feet wide.

JUNCTION PORT: A sector junction which is defined as a port equivalent for operational purposes within a simulation model. In some cases it may be necessary to define port equivalents at sector junctions which neither originate nor terminate cargo, in order to model fleeting areas. Thus, junction ports differ conceptually from port equivalents, since they do not necessarily represent a collection of docks. In all other respects, however, a junction port is identical to a PE and to an APE.

KNOBS: Input parameters that influence model activities and are not obtained by observation and/or measurement of real-world conditions, and that regulate model operations which are not or cannot be simulated precisely. Knobs can be used to fine-tune a model. Some examples of knobs are the speed coefficient, the travel time limit for light boats, the loaded/empty tow cutoff tonnage, the tow stopping delay, and the barge pickup/dropoff delay.

KNOCKOUT LOCKAGE: A type of lockage in which the towboat alone is separated from its barges and set alongside of them in the lock chamber.

KORT NOZZLE: A funnel-shaped structure built around the propeller of a tow boat to concentrate the flow of water to the propeller.

LASH: Lighter aboard ship; an international trade containerized cargo transportation system featuring shallow draft barges used for inland distribution which are carried in a ship over the oceans. Lash barges are 70 feet long and 31 feet wide.

LIGHT BOAT: A towboat without barges.

LINE HAUL: The transporting of items or persons between terminals excluding local deliveries or movements.

LINE-HAUL LINKS: In multimodal network terminology, line-haul links represent the transportation facilities that make up the multimodal network. A single line-haul link might represent a given waterway, reach, a single-track or double-track rail line, a primary highway, or a section of a pipeline. Line-haul links are identified by specifying the nodes at each end of a link. Attributes used to model line-haul link operations include length, capacity and link class.

LINKS: In waterway network terminology, ports, locks, and the reaches between ports and locks are called links. These links represent the physical waterway features with which tows interact directly. Ports and locks are often referred to as nodes because they represent points as opposed to reaches which have length. (See WATERWAY NETWORK.)

LOADING/UNLOADING RATE: The handling rate, which is the time (in minutes) required to load or unload a ton of cargo into/out of a barge. These rates are given for each of three cargo handling classes: (1) dry, large granular bulk and packaged cargo, (2) dry, fine granular bulk cargo, and (3) liquid cargo.

LOCK: A facility containing one or more than one enclosed chamber, situated at a point (canal or dam) on a waterway, with gates at each end, for raising or lowering vessels by admitting or releasing water. (See CHAMBER.)

LOCKAGE: Passage of a tow or other vessel through a lock. The series of events required to move a vessel or tow through a lock in a single direction. More than one vessels cut or tow can be processed at the same time during a single lockage. A normal lockage cycle consists of an approach, entry, chambering and exit.

LOCKAGE FEE: The user charge, in dollars per lockage, to be levied at the lock.

LOCKAGE TIME: The time elapsed from the start of approach of the first vessel or cut served by a lockage to the end of exit of the last vessel or cut served by a lockage. Includes the time required to disassemble and assemble multiple-cut tows and to rearrange setover tows, when such activities prevent the use of the lock by other vessels.

LOCK CHAMBER: (See CHAMBER.)

LOCK NUMBER: A number sequentially assigned to lockage facilities for identification purposes.

LOCK OM&R EXPENDITURES: Government operation, maintenance and rehabilitation expenditures for the locks in a given river segment, in thousands of dollars per year.

MAIN CHAMBER: The larger or largest chamber, through which most of the traffic moves at a given multiple-chamber lock. (See LOCK CHAMBER.)

MAIN CHAMBER IDENTIFICATION: The identification number of the principal lock chamber class at the lockage facility.

MAIN PROGRAM IN A SIMSCRIPT PROGRAM: The major program feature which sets the values of the variables defined by the PREAMBLE feature of a SIMSCRIPT program, in order to make the variables conform to the particular system being modeled. It does this by reading an extensive set of system data which creates a mathematical abstraction of the system being modeled. This process is referred to as configuring the model. (See PREAMBLE IN A SIMSCRIPT PROGRAM.)

MAXIMUM BARGE CAPACITY: The maximum barge capacity, in tons, for types of cargo typically carried. Actual barge capacities are computed from cargo densities.

MAXIMUM TOW SIZE: The largest size tow allowed on the sector, expressed in nominal barge units.

MODEL CALIBRATION: An effort to demonstrate that a simulation model actually does simulate a system's performance. After establishing an appropriate warm-up period, one of two types of model calibrations is generally undertaken: (1) The initial calibration of a model, often referred to as the validation of the model, is the basis for acceptance or rejection of the model.(2) The re-calibration of a model, which is performed after each major change in the system being simulated, is the usual method by which the simulation performance of a model is checked and appropriately adjusted if necessary. Models are calibrated by manipulating input data and making iterative model runs until key model output parameters converge to an acceptable range of values. The range of values is judged acceptable if it conforms with already validated statistics. (See STEADY STATE.)

MULTIMODAL NODES: Terminals, link delimiters, and locations in general where line-haul transportation facilities intersect and traffic is permitted to switch from one facility to another. Multimodal nodes are also used to identify points of access to a multimodal transportation network, and/or locations where characteristics of line-haul facilities change. A multimodal node might represent a river port or junction, rail yard, highway intersection or pipeline terminal.

MULTIPLE-CUT LOCKAGE: The type of lockage performed when a tow must be passed through the lock into two or more segments or "cuts."

MULTIPLE-VESSEL LOCKAGE: A type of lockage in which more than one vessel or tow is served in a single lockage cycle.

NAVIGABLE DAM: A dam which permits the passage of vessels without the use of a lock during periods of high water.

NAVIGABLE PASS: The passage of a vessel over a navigable dam without the use of a lock.

NETWORK: See WATERWAY NETWORK.

NODES: Ports and locks are often referred to as nodes because they represent points as opposed to reaches which have length. (See LINKS and REACHES.)

NOMINAL BARGE UNIT: A nominal barge unit for a given class of barge is determined (defined), outside a model, by systematically selecting, from the barge class, one barge-type as a standard and designating the size of the standard as one nominal barge unit. The sizes of other barges are calculated relative to the size of one nominal barge unit.

NUMBER OF BARGE CLASSES: The maximum number of barge classes in the network data.

NUMBER OF COMMODITY CLASSES: The maximum number of commodity classes in the network data.

NUMBER OF LOCKS: The maximum number of locks in the network data.

NUMBER OF LOCK CHAMBER TYPES: The maximum number of lock chamber classes in the network data.

NUMBER OF PORTS: The maximum number of ports in the network data.

NUMBER OF RIVER SEGMENTS: The maximum number of river segments into which a waterway network is divided.

NUMBER OF SECTORS: The maximum number of river sectors into which a waterway network is divided.

NUMBER OF TOWBOAT CLASSES: The maximum number of towboat classes in the network data.

NUMBER OF TRANSPORTATION CLASSES: Maximum number of transportation classes in the network data.

N UP - M DOWN: A lock operating policy in which up to N upbound vessels are serviced, followed by up to M downbound vessels, where N and M are positive integers.

N UP - N DOWN: A commonly used special case of N up and M down, in which N and M are equal.

OPEN HOPPER BARGE: A barge which is basically a doubled-skinned, open-top box, the inner shell of which forms a long hopper or cargo hold.

OPEN PASS: Passage of a vessel through a lock with no lock hardware operation. This is possible only when the upper and lower pool levels are nearly equal, and occurs most frequently at tidal locks.

OPTIMIZATION MODEL: In computer model terminology, an optimization model is a computer program that was developed to analytically process mathematical and scientific problems to achieve an optimal solution-objective, which is to determine the best result (greatest degree) obtainable under specific conditions. The Tow Cost Model (TCM) is essentially an optimization model.

ORIGIN SECTOR: The sector in which the origin port is located.

OTHER CORPS OF ENGINEERS OM&R EXPENDITURES: OM&R costs other than lock costs and Coast Guard expenses, in thousands of dollars per year.

OUTPUT PROCESSING ROUTINES IN A SIMULATION PROGRAM: Routines that use statistics gathered during the simulation to generate output, such as performance reports on lock utilization and delay, towboat and barge utilization, port activity, detailed traffic summaries by reach and other optional reports specified by a user.

PE: See PORT EQUIVALENT.

PERFORMANCE MONITORING SYSTEM (PMS): A standardized system of lockage data collection and analysis which was introduced by the U.S. Army Corps of Engineers in 1975, to enable Corps planners and operations personnel to help the Corps of Engineers carry out more effectively its responsibility to operate and maintain the Nation's inland waterways system.

PICKUP WAITING TIME FACTOR: The average length of time that a group of barges waits for a towboat after being loaded, expressed in hours per barge in the group.

PMS: See PERFORMANCE MONITORING SYSTEM.

POOL: The body of water impounded by a navigation dam.

PORT: A waterway shoreline facility which can be a destination or origin for a shipment, where towboats can pick up or drop off barges, and where barges are loaded and unloaded. (See PORT EQUIVALENT and AGGREGATE PORT EQUIVLENT.)

PORT-TO-PORT ALGORITHM: The Port-to-Port Algorithm is the name given to the procedure by which the Resource Requirement Model (a component of the Tow Cost Model) evaluates the time and cost required to transport cargo between a given pair of ports using a given towboat class. The procedure is based on a round trip which moves shipments in both directions between two ports under consideration. Essentially, for each combination of transportation class and origin-destination pair of ports, the model iterates through various towboat classes and possible fleeting decision to determine an optimum "least cost tow" routing scenario. For the purpose of analysis, the round trip is divided into seven activities, or functions:

- Cargo loading and unloading
- Waiting for access to docks (to begin loading and/or unloading)
- Barges waiting for pickup by a towboat
- Tow makeup and breakdown
- Travel on waterway links
- Lockage operations
- Delays at locks

Shipping costs arise from four sources in the model:

- Towboat operating costs
- Barge operating costs
- Cargo inventory costs
- Lockage and segment tolls (other user fees are included in towboat operating costs and barge operating costs.)

The Port-to-Port Algorithm is the heart of the Resource Requirement Model and the key assumptions underlying the model are embedded within the algorithm. A central assumption of the algorithm is that cargo movements between the ports can be treated as if they are handled by a dedicated set of towboats and barges which shuttle between the ports. In practice, of course, most tows operate in a more flexible fashion, picking up and dropping off barges at intermediate points along their routes. However, while such operations can strongly affect the routing and scheduling of individual tows, their impact on overall equipment productivity, and hence, equipment requirements, is not considered as being large. Nevertheless, the algorithm indirectly accounts for the existence of intermediate pickups and dropoffs in several areas where the shuttle assumption is believed to be too extreme.

PORT DELAY: The average delay in the peak season for a tow to gain access to port loading/unloading facilities, expressed in hours per tow for each of three cargo handling classes (see LOADING/UNLOADING RATES). This number may have an undesirable effect on model output since port access times are determined by a queuing theory function.

PORT EQUIVALENT (PE): Groups of docks that are abstracted as points or network nodes because there are far too many docks to be represented individually in a simulation model, and since port operations are not of primary concern in waterway simulation. To represent every dock individually in a waterway simulation would be prohibitively expensive. (See PORT.)

PORT NUMBER: A number assigned sequentially to ports for identification purposes.

POSTPROCESSOR MODEL: A computer model that processes the output of a main model, or another model, to produce a variety of output reports at different levels of detail. A postprocessor model, in general, does not perform complicated calculations.

PREAMBLE IN A SIMSCRIPT PROGRAM: The program feature which defines a simulation model by setting up the relationships among events (things that happen), entities (things that are changed by an event), attributes (aspects of an entity), and sets (places to store entities when they are not involved in an event). First, it defines the structure of the sets, entities and attributes of the permanent variables used throughout the model, and then, it defines the events in the model.

PREPROCESSOR MODEL: A computer model that processes data before they are input to a main model. Some main models, such as the Waterway Analysis Model, require very large amounts of data, which are checked for errors by a preprocessor model before being input to the main model.

PRIVATE CARRIER: A company engaged in transporting its own goods in its own vehicles, or goods for which the vehicle owner is lessee or bailee.

PRODUCTION FUNCTION: The term "production function" is applied to the physical relationship between a firm's inputs of resources and its output of goods or services per unit of time, leaving prices aside.

REACH: In waterway network terminology, a reach is a section of a waterway network between two ports, or between two locks, or between a port and a lock. A reach is the only network element with a nonzero length.

RECORD: A meaningful group of data elements. A logical record is composed of a number of data elements which contain values relevant to a particular entity (record). The term physical record is used to describe a group of logical records that are treated as a single unit for the purpose of input or output.

The blocking or grouping of logical records on magnetic tape is an example of a physical record which is stored on a storage medium as a single physical record and is treated in internal memory as separate logical records.

RECREATIONAL CRAFT: All vessels which are not commercial tows (towboats and/or barges) are recreational craft, for the purpose of operating the inland systems analysis models. The models are not concerned with recreational craft, per se, only with their influence on commercial traffic. The arrival rate of recreational crafts is specified separately for each lock where recreational crafts are taken into account.

REGION: The geographic area, represented by a set of large subareas, which contain the transportation system to be analyzed. The subareas are called regions, and they must be closed and nonoverlapping and collectively account for all of the economic activity and commodity flows to be included in the analysis.

RIVER MILE: A number specifying the location of a point along a waterway, obtained as the distance from a reference point designated as mile zero.

RIVER SEGMENT: A waterway network is a set of river systems, and each river system consists of one or more segment. Each segment consists of one or more sectors. Each sector is divided into links. Each link represents a port, or a lock, or a reach between a port and a lock. (See NODES.) Each reach is a section of a network between two ports, or between two locks, or between a port and a lock. Typically, a segment would consist of all the sectors that make up a particular river.

RIVER SEGMENT NAME: The name assigned to a river segment.

RIVER SEGMENT NUMBER: A sequential identification number assigned to a river segment.

RIVER SEGMENT TOLL: A user fee, in mills per ton-mile to be charged to traffic using a given river segment.

RIVER SYSTEM: A river system is the highest element in the hierarchy of a waterway network. It is also a collection of sectors and is used to collect statistics and to organize model output. A river system is arbitrarily defined by a user and can be used to divide a network into segments that are operationally facilitative. (See WATERWAY NETWORK.)

ROUTING MATRIX: A table that is used, in the waterway network context of the Tow Cost Model, to determine routes between ports, by producing the sequence for traversing connecting sectors. The table consists of a matrix with a row and a column for each sector. For example, the route from a port located in sector i to a port located in sector j is determined by searching the table to find the (i,j) entry which gives the next sector to be entered after leaving sector i. If the next sector to be entered were sector k, the table would be searched to find the (j,k) entry. The route determination process would be continued until the next sector to be entered is the last sector to be encountered. In cases where more than one route exist between a pair of sectors, the process would select the shortest route based on the distances between sector midpoints.

RUN CONTROL DATA: Records that cause events such as the resetting of accumulated statistics, the printing of intermediate output reports, the saving of optional data and the end of simulation.

SEABEE: An international trade containerized cargo transportation system featuring shallow draft barges used for inland distribution which are carried in a ship over the oceans. Seabee barges are 95 feet long and 35 feet wide.

SEASON: The season, which is numbered 1 to 4, when a shipment occurs. The season number 1 = winter, 2 = spring, 3 = summer, and 4 = fall.

SEASONALITY FACTOR: The resultant number (quotient) derived by dividing the tonnage transported in the peak season, by the tonnage transported in the average season. A seasonality factor is calculated for each transportation class and for each link in a system. The factor is equal to 1.0 when the commodity flows in each season are identical and could range up to 4.0 if all traffic was concentrated in a single season.

SECOND PORT: The second port of a selected pair of ports. Note that various reports will reflect movements in both directions between the two ports, therefore, the second port is not necessarily the original port of destination.

SECTOR: An unbranched section of a waterway network on which certain tow operating limitations are uniform. Sectors always begin and end at ports (PE or APE). Typically, a sector extends from one river junction to another or to a system end point, although such a one-sector segment can be divided into two or more sectors if significant differences in characteristics exist along its length. Each sector in a system is assigned a sequential numeric identifier. (See WATERWAY NETWORK.)

SECTOR DESIGNATION BY TOWBOAT CLASS: In INSA network terminology, the use of the sector designation control to institute shuttles whereby towboats operating only on a tributary could transport cargo in small tows to and/or from a mainstream, where the cargo would be picked up and/or dropped off by larger tows. This control assures that towboat classes remain in system areas which are commensurate with their size and power. (See SHUTTLE OPERATIONS.)

SECTOR NUMBER: A sequential numeric identifier assigned to a sector. A sector number is used as the first part of the shipment-list identifiers for ports of origin and ports of destination.

SETOVER LOCKAGE: A lockage in which the towboat and one or more barges are separated as a unit from the remaining barges and set alongside of them in the lock chamber. The term is usually applied only to single lockages, but it could be used to describe any cut. The term is often used to refer to all types of single lockages requiring rearrangement of the tow.

SETOVER PROBABLITY: The fraction of potential setover lockages which are actually setovers.

SHIPGEN PROGRAM: A program, written in FORTRAN and developed by the Pittsburgh District, that generates shipments in the WAM format for a 28-day time period based on commodity flow information. An input factor, one for each commodity, converts the tonnage to 28-day flows. The basis for using a period of 28 days is that it is close to 1 month, but still is a whole number of weeks (divisible by 7).

SHIPMENT DATA: A set of demands for the movement of commodities. Each movement demand is specified by commodity class, tonnage, origin, destination, and time of availability for shipment.

SHIPMENT LIST: A stream of shipment demands which is input to a model during execution. Each shipment demand contains the following data: commodity class, tonnage, origin, destination, and time of cargo arrival at the origination port or port equivalent.

SHUTTLE OPERATIONS: Cargo movement in a shuttle pattern, between a pair of ports that results from flagging designated shipments as dedicated, by including on the shipment data card a special code called a dedication index. Selected towboats and barges from one or more classes are given the same dedication index. The dedicated shipment is allowed to be transported by the model, only after the required dedication-index-match has been made among the flagged cargo, flagged barges and flagged towboats.

SILL: A transverse structural element of a lock chamber upon which the lock gates rest when they are closed; the upstream or downstream boundary of a lock chamber.

SIMSCRIPT II.5: A version (level) of a computer programming language that was developed specifically for simulation modeling. SIMSCRIPT II.5 works on the assumption that the events to be modeled occur in a time sequence. It handles the first event before the second, the second before the third, etc. This time is maintained in "system time" kept by the "system clock," (See SYSTEM CLOCK AND SYSTEM TIME.)

SIMULATION MODEL: In computer model terminology, a simulation model is a computer program that was developed to analytically process an assemblage of parts forming a complex or unitary whole, for the primary purpose of simulating the operation of the parts as a whole system, under specific conditions. Operating conditions may be specified differently for each simulation. To assure that a simulation model will make a valid simulation run, the model must be calibrated before the run is made.

SIMULATION PROGRAM: The operational heart of waterway systems simulation models. It processes the input data, produces playback reports, initializes the waterway system, processes each shipment from origin to destination, records statistics for generation of performance output reports, and creates files for postprocessing by other programs.

SINGLE LOCKAGE: The type of lockage performed when the entire tow can fit into the lock chamber, with or without rearrangement, and hence, requiring only one lock operating cycle.

SINK: In transportation terminology, sink is the opposite of commodity source. A sink is a place or region to which specific kinds of commodities would be characteristically transported for use in processing other materials or other commodities.

SPLC: A contraction of Standard Point Location Codes. The codes are defined and published in the "Continental Directory NMF 102-B" containing an alphabetical arrangement of motor carrier points in the United States of America and Canada, and an alphabetical arrangement of rail stations in the United States of America. The directory is published by the National Motor Freight Traffic Association, Incorporated, located at 1616 P Street, N.W.; Washington, D.C. 20036.

STANDARD BARGE: A barge 175 feet long and 26 feet wide.

STEADY STATE: A condition that exists essentially when tne probability distributions of a simulated system's descriptive variables are not changing with time. An analyst is generally interested in having the simulated system achieve a steady state before using a simulation model for actual collection of statistics. To initialize a system to a steady state, it is now standard practice to use a "warm-up" period to pre-position all variables and to rewind the input data file(s).

STRAIGHT LOCKAGE: A lockage which does not require rearrangement of the tow in order for the tow to fit into the lock chamber. The term is usually applied only to single lockages, but it could be used to describe any cut. (See SINGLE LOCKAGE.)

STRAIGHT SINGLE: (See STRAIGHT LOCKAGE, and SINGLE LOCKAGE.)

SWITCHBOAT: A towboat used to assist tows requiring a multiple-cut lockage. A switch boat may be used to assist a tow in entering or exiting the lock chamber, or it may independently power a cut through the lock. A switchboat usually stays at a given lock.

SYSTEMS ANALYSIS: The analytical determination of the essential features and interdependencies of an assemblage of parts forming a complex or unitary whole.

SYSTEM CLOCK: A feature in the SIMSCRIPT computer programming languages, whereby the events to be modeled (simulated) are time-sequenced by the feature (system clock). The feature determines which event is to be performed next, and is the source for all of the time calculations in a simulation model and written in SIMSCRIPT. Choosing the next event is an automatic feature in SIMSCRIPT languages and does not appear in either the program code of any model or in any of the inputs or outputs. (See SYSTEM TIME.)

SYSTEM TIME: The time which is kept by the system clock in a simulation model that is written in SIMSCRIPT. In such a model, the sequencing of events is kept track of in terms of system time. An event is scheduled by computing in advance how long from a previous event a current event will occur and putting that current event and its time in a pending file. During simulation, when the system clock reaches the time of the earliest pending event, it will process that event. See SYSTEM CLOCK.

TANK BARGE: A barge used to transport liquid commodities in bulk.

TANKER TIME FIXTURE: See TIME FIXTURE.

TANKER VOYAGE FIXTURE: See VOYAGE FIXTURE.

TCM: See TOW COST MODEL.

TIME FIXTURE: A charter fixture that contains the elements of time information relevant to a mercantile lease of a of a ship or some principal part of a ship. See CHARTER FIXTURE. A time fixture may be a dry time fixture or a tanker time fixture, and will characteristically contain information such as shown below:

Dry Time	Tanker Time
1. Charterer's Name	1. Cargo Type
2. Comments	2. Charterer's Name
3. Cubic Capacity	3. Comments
4. Date of Update	4. Date of Update
5. Deadweight	5. Deadweight
6. Delivery Area	6. Fixture Date
7. Fixture Date	7. Fixture Number
8. Fixture Number	8. Fixture Type
9. Fixture Type	9. Fuel Consumption
10. Fuel Consumption	10. Lay/Cancel Days
11. Lay/Cancel Days	11. Period of Charter
12. Period of Charter	12. Rate
13. Rate	13. Redelivery Date
14. Redelivery Area	14. Ship's Name
15. Redelivery Date	15. Speed
16. Ship's Name	16. Source Code
17. Speed	
18. Source	

TIME OF AVAILAILITY OF SHIPMENT: The time when a cargo will be delivered to its port of origin and will be available for transportation to its port of destination.

TOFC: Trailer on flatcar.

TON: A unit of weight equal to 2,000 pounds avoirdupois (907.20 kilograms); a short ton.

TON-MILE: A unit of transportation production equal to the movement of 1 ton a distance of 1 statute mile.

TOTAL DELAY OF A TOWBOAT AT A PORT: The sum of the tow stopping delay plus the product of the barge pick up and drop off delay multiplied by the number of barges involved in the exchange.

TOW: A towboat and one or more barges which are temporarily fastened together and operated as a single unit.

TOWBOAT: A shallow-draft commercial vessel used to push or pull barges.

TOWBOAT BLOCK COEEFICIENT: A factor reflecting the shape of the towboat. It is used in the calculation of the speed function. (See BLOCK COEEFICIENT.)

TOWBOAT CLASSES: The definitions and descriptions of the types of towboats. Each class of towboat is described in terms of horsepower, dimensions, towing capacity, area of operation, class name, and the sequential identification number assigned to the class. In general, the classes define towboats that are representative of the mix found in practice.

TOWBOAT CLASS NUMBER: A sequential indentification number assigned to the class.

TOWBOAT DESCRIPTION: The name of the towboat class.

TOWBOAT DRAFT: The overall draft, in feet, of the towboat under full load operating conditions.

TOWBOAT LABOR COST: Average labor cost of operating the boat, in dollars per hour.

TOWBOAT REGISTRATION FEE: The annual towboat registration fee, in dollars per horsepower.

TOWBOAT TOWING CAPACITY: The maximum number of nominal barges that can be pushed by a towboat.

TOW COST MODEL (TCM): A model consisting of two principal computer programs, the Resource Requirements Model which determines the least cost system-wide towboat and barge requirements, and the Postprocessor Routine which provides cost analysis reports for pairs of ports (origin and destination) selected from the waterway by the model user.

TOW SIZE: The quantity, dimensions, drafts, capacities, and classes of the units of equipment that compose a given tow (towboats and barges).

TOW SIZE DESIGNATION BY SECTOR: The maximum tow size designated for each sector.

TOW STOPPING DELAY: The simulated time required by a towboat to drop off or pick up barges. It represents an "overhead" time to lash a set of barges to the towboat to form a tow.

TRAINING WORKS: Structures such as levees or revetments placed along river channels to increase runoff capacity, prevent bank erosion, and stabilize the location of the channel.

TRANSFER LINKS: In multimodal network terminology, transfer links represent intermodal transfer or interface facilities, such as riverside coal transloaders, container terminals, grain elevators serving lengthy truck hauls, and all types of rail-barge, truck-rail and truck-barge terminals.

TRANSPORTATION BARGE TYPE: The identification number of the preferred type of barge to carry cargo in the transportation class.

TRANSPORTATION CLASS: A transportation class is defined as an aggregate of commodity classes that have similar characteristics with respect to transportation functions. Each commodity class is assigned to a specific transportation class.

TRANSPORTATION CLASS NUMBER: A sequentially assigned identification number for the transportation class.

TSC: Transportation System Center of the U.S. Department of Transportation.

TUNNEL STERN: A towboat design feature in which part of the propeller is above the level of the water surface in a spoon-shaped recess in the bottom of the hull which is filled with water by vacuum action when the propeller is turning.

TURNBACK: A lockage in which no vessels are served; a reversal of the water level in a lock chamber with no vessels in the chamber. A turnback includes closing one set of gates, filling or emptying the chamber, and opening the other set of gates. Also called a "swingaround" or an "empty lockage."

TURNBACK APPROACH: The type of approach executed when the preceding event at the lock was a chamber turnback.

TURNBACK EXIT: The type of exit executed when the preceding event at the same direction, requiring a chamber turnback.

UNIFORM SEGMENT TOLL: The value of a system-wide segment toll, in mills per ton-mile.

VESSELS: In model terminology, vessels are the towboats and barges. Vessels are the active elements of inland waterway transportation because they move cargo through the waterway network. In simulation models and in optimization models, vessels are represented explicitly. Each vessel retains its individual identity throughout the period of simulation (WAM) or optimization (TCM). Vessels (towboats and barges) are organized into classes. All vessels of the same class are treated as being identical.

VOYAGE FIXTURE: A charter fixture that contains the elements of voyage information relevant to a mercantile lease of a ship or some principal part of a ship. See CHARTER FIXTURE. A voyage fixture may be a dry voyage fixture or a tanker voyage fixture, and will characteristically contain information such as shown below:

Dry Voyage	Tanker Voyage
1. Cargo Quantity	1. Cargo Quantity
2. Cargo Type	2. Cargo Type
3. Charterer's Name	3. Charterer's Name
4. Comments	4. Comments
5. Consecutive Voyages	5. Consecutive Voyages
6. Date of Update	6. Date of Update
7. Discharge Area	7. Discharge Area
8. Fixture Date	8. Fixture Date
9. Fixture Number	9. Fixture Number
10. Fixture Type	10. Fixture Type
11. Lay/Cancel Days	11. Lay/Cancel Days
12. Loading Area	12. Loading Area
13. Rate	13. Rate
14. Ship's Name	14. Ship's Name
15. Source	15. Source Code
16. Terms of Charter	

WAM: See WATERWAY ANALYSIS MODEL.

WARM-UP PERIOD: See STEADY STATE.

WATERBORNE COMMERCE STATISTICS CENTER (WCSC): A component of the U.S. Army Corps of Engineers Water Resources Support Center which is located at Fort Belvoir, Virginia. The mission of the WCSC is embodied in the assignments listed below:

- Collect domestic vessel and cargo movement data from carriers engaged in commercial transportation on the navigable waterways of the United States.
- Compile and produce freight traffic and vessel trip and draft statistics for the waterways and harbors of the United States.
- Compile and produce freight traffic and vessel trip and draft statistics for the major ports of the United States.
- Compile water commerce freight tonnage and ton-mile statistics for the United States as a whole.
- Assemble the statistics described above for annual publication in the Corps of Engineers document entitled "Waterborne Commerce of the united States."
- Inventory the U.S. flag vessels in commercial use throughout the nation publish the inventory in the three-part series of the publication entitled "Transportation Lines of the United States."

- Respond to requests for special statistical data on annual waterway traffic not otherwise available in published statistical form, while keeping the Corps of Engineers commitment to preserve the confidentiality of source data.

WATERWAY: Any body of water wide enough and deep enough to accommodate the passage of water craft, particularly commercial vessels.

WATERWAY ANALYSIS MODEL (WAM): A detailed, relatively large, and generalized model that uses a large-scale computer to simulate the waterborne transportation of commodities on an inland waterway system. The system is hypothesized to operate under various economic and technical conditions. In its production of waterway performance predictions on which assessments of system adequacy are based, the WAM provides and uses explicit representations of individual waterway facilities, cargo consignments, and vessels. Listed below are osme of the other inland waterway management activities for which the WAM also provides support:

- Benefit evaluation and allocation
- Long-range programming and capital budgeting
- Environmental impact analysis
- Analysis of navigation policy options
- Interfacing with multimodal transportation planning
- Evaluation of lock and waterway operating procedures
- Preliminary screening of port capacity adjustments
- Forecasting future requirements for towing equipment
- Evaluating of towing industry performance

WATERWAY NETWORK: A waterway network is a set of river systems. Each river system consists of one or more segments. Each segment consists of one or more sectors. Each sector is divided into links. Each link represents a port, or a lock, or a reach between a port and a lock. (See NODES.) Each reach is a section of network between two ports, or between two locks, or between a port and a lock. Typically, a segment would consist of all the sectors that make up a particular river.

WATERWAY NETWORK STRUCTURE IN A SIMULATION MODEL: The representation of the waterway network structure as a hierarchy of elements such as river systems, segments, sectors and links. (See WATERWAY NETWORK.)

WCSC: See WATERBORNE COMMERCE STATISTICS CENTER.

REFERENCES

The following list contains only those references that have a substantial amount of technical and/or user documentation. To obtain detailed information on the following or additional reference/user manuals, Corps of Engineers personnel may request assistance from the contact person designated in the Location and Availability Section which is found on the first page of the descriptive passage for each entry in Chapters II and III. The references below are listed in th eorder that thy appear in the text of this report.

CHAPTER II

COMMODITY FLOW MODEL (CFM)

U.S. Army Corps of Engineers, Office of the Chief of Engineers, Civil Works Directorate, Inland Navigation Systems Analysis (INSA) Program. July 1976. INSA Reports, Volume III, Commodity Flow Model. Washington, D.C.

TRANSPORTATION FREIGHT MODEL (TFM)

U.S. Army Corps of Engineers, Institute for Water Resources, Navigation Analysis Center. November 1980. Analysis of Transportation Network Model and Applications to Coal Market Studies. Fort Belvoir, Virginia.

U.S. Army Corps of Engineers, Office of the Chief of Engineers, Civil Works Directorate, Inland Navigation Systems Analysis (INSA) Program. July 1976. INSA Reports, Volume IV, Multimodal Analysis Model. Washington, D.C.

TOW COST MODEL (TCM)

U.S. Army Corps of Engineers, Huntington Engineer District. June 1981. Methodology for Inland Navigation Systems Benefit Analysis. Unpublished Working Draft Paper. Huntington, West Virginia.

Part 1: Tow Cost Model
Part 2: Marginal Economic Analysis Program
Part 3: User's Manual

LOCK CAPACITY FUNCTION GENERATOR (LOKCAP)

U.S. Army Corps of Engineers, Office of the Chief of Engineers, Civil Works Directorate, Planning Division. September 1979. Improvement of the LOKCAP Model to Handle Double Chamber Queuing. Washington, D.C.

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U.S. Army Corps of Engineers, Pittsburgh Engineer District. January 1982. Waterway Analysis Model. Four volumes. Pittsburgh, Pennsylvania.

Volume I,	Main Report.	
Volume II,	Appendix A:	User's Manual.
Volume III,	Appendix B:	Model Structure.
Volume IV,	Appendix C:	Pre-processing and Post-processing.
Volume IV,	Appendix D:	ANALYZE Program for Comparison of Output.

CHAPTER III

PERFORMANCE MONITORING SYSTEM (PMS)

U.S. Army Corps of Engineers, Institute for Water Resources, Navigation Analysis Center. November 1982. User's Guide for the Lock Performance Monitoring System. Draft report. Fort Belvoir, Virginia.

WATERBORNE COMMERCE STATISTICS

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Package 1:	DOCK-TO-DOCK Data File
Package 2:	PORT/PORT EQUIVALENT Data File
Package 3:	REGIONAL WATERWAYS Data File

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Maritime Data Network, Ltd. 1980. Ship Characteristics Library. 300 Broad Street. Stamford, Connecticut.

CHARTER FIXTURE LIBRARY (MARDATA/CF)

Maritime Data Network. Ltd. 1981. Charter Fixture Library. 300 Broad Street. Stamford, Connecticut.

RIVER POINT DIRECTORY FOR THE MISSISSIPPI RIVER-GULF COAST INLAND WATERWAYS SYSTEM

U.S. Army Corps of Engineers, Waterways Experiment Station. May 1975. River Point Directory for the Mississippi River-Gulf Coast Inland Waterways System. Vicksburg, Mississippi.

PHYSICAL CHARACTERISTICS OF INLAND WATERWAYS

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☆ U.S. GOVERNMENT PRINTING OFFICE : 1983 O - 410-186